REPORT

ON THE

MAGNETIC ISOCLINAL

AND

ISODYNAMIC LINES

IN THE

BRITISH ISLANDS.

FROM OBSERVATIONS BY

PROFESSORS HUMPHREY LLOYD, AND JOHN PHILLIPS; ROBERT WERE FOX, ESQ., CAPT. JAMES CLARK ROSS; AND MAJOR EDWARD SABINE.

BY

MAJOR EDWARD SABINE, R.A., F.R.S.

[TWO SECTIONS OF THE REPORT ARE WRITTEN BY PROFESSOR LLOYD.]

[WITH PLATES.]

[*From the* EIGHTH REPORT *of the* BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.]

LONDON:

PRINTED BY RICHARD AND JOHN E. TAYLOR,

RED LION COURT, FLEET STREET.

1839.

A Memoir on the Magnetic Isoclinal and Isodynamic Lines in the British Islands, from Observations by Professors Humphrey Lloyd and John Phillips, Robert Were Fox, Esq., Captain James Clark Ross, R.N., and Major Edward Sabine, R.A. By Major EDWARD SABINE, R.A., F.R.S.

AT the meeting of the British Association, held at Cambridge in the year 1833, a resolution was passed, recommending that a series of determinations of the magnetic dip and intensity should be executed in various parts of the United Kingdom.

Early in 1834 Professor Lloyd, who had attended the meeting at Cambridge, proposed to me to unite with him in carrying the recommendation of the Association into effect as far as regarded Ireland. I was at that time employed on the staff of the Army in the south-west district of Ireland, and found it not incompatible with other duties to undertake that portion of the island. Our observations were continued at intervals throughout that year, and until the autumn of 1835, in the summer of which year we were joined by Captain James Clark Ross. A report of our operations, drawn up by Professor Lloyd, was made to the British Association, assembled in that year in Dublin, and was printed in 1836 in the fourth volume of the Association Reports. A re-calculation of the Irish results, incorporating the observations which have been made since in that part of the United Kingdom, has been furnished by Mr. Lloyd, and occupies its appropriate place in this report.

Mr. Robert Were Fox, who was present at the Dublin meeting in 1835, brought with him an apparatus for magnetic observations on a new construction of his own invention, with which, after the meeting, he made several observations of the dip in the course of a tour in the west and north of Ireland. These observations, with others made on his return through Wales, were published in 1836, in the report of the Royal Polytechnic Society of Cornwall for 1835. Several of these observations were made in houses, and were consequently liable to disturbing influences. Mr. Fox has selected eight determinations of the dip in Ireland, and nine in Wales, as free from objection on this account; and with his permission they are now incorporated in the present report.

Having obtained two months leave of absence from military duty in the summer of 1836, I employed them in extending the survey to Scotland, by observations at twenty-seven stations dis-

tributed over that country, forming the basis of a memoir on the Scottish Isoclinal and Isodynamic lines, which was printed in the fifth volume of the Association Reports, and published in 1837

In the same summer Professor Lloyd commenced the magnetic survey of England by a series of observations at fourteen stations, principally in the midland and southern districts, these observations have not been hitherto published, and will be found in their place in the present memoir

The interest which had been excited at the meetings of the British Association by the Irish and Scotch Magnetic Reports, induced Professor Phillips to provide himself with an apparatus for the dip and intensity, having particularly in view the investigation of the influence which he deemed it possible the configuration of the surface, or the geological character of the district, might have on the position or on the inflexions of the lines representing these phænomena. In the summer of 1837 Mr Phillips visited and observed at twenty-four stations in England, chiefly in the northern district; these observations are now first published.

In the same summer Mr Fox determined the dip at twenty stations in the north of England and south of Scotland; and in the summer of 1838 at eight stations in the south of England, extending from London to the Scilly islands; at some of the latter stations he also observed the intensity these observations form part of the present memoir.

In August 1837 Captain James Ross commenced a series of magnetic observations, which he continued almost uninterruptedly until the close of 1838; they extend over England, Ireland and Scotland generally, and comprehend fifty-eight stations His observations of the dip and of the intensity are included in the present memoir.

Lastly, between August 1837 and October 1838, I have taken advantage of an interval between military duties, to observe the dip and intensity at twenty-two stations, distributed for the most part round the coasts of England and Wales, and extended into Ireland and Scotland for the purpose of accomplishing a more complete connexion of the different series.

It has been the wish of the four gentlemen connected with me in this undertaking, that I should draw up the memoir of what our joint labours have accomplished. Our observations have been now carried over the whole extent of England, Ireland and Scotland; and may be considered in their combination, and by their extent, to obtain, in some measure, the character of a national work; presenting to the immediate requisitions of

science, the actual state of the phænomena of the magnetic dip and intensity in the British islands; and furnishing for distant times the means of a comparison, whereby the secular changes of these elements may be correctly judged of.

It has been found convenient to divide the report into two parts, the first comprising the observations of the Dip, the second those of the Intensity.

Division I.—*Dip.*

In the memoir on the magnetical observations in Ireland (British Association Reports, vol. v.), Mr. Lloyd has noticed the discrepancies which have been occasionally found in the results of observations of the dip made at the same station with different instruments. The observations of Captain Ross at Westbourne Green, which are there related, place these discrepancies in the strongest light. Captain Ross employed eight needles, making from eight to ten observations with each, each observation consisting of eighty readings, i. e. of ten in each of the eight usual positions. The dip at Westbourne Green, resulting from each of these needles considered separately, varied from 69° 01′.5 to 69° 42′.6. On these discordances Mr. Lloyd remarks as follows; "Thus it appears that there is a difference amounting to 41′ in the results of two of the needles used, and that the difference is very far beyond the limits of the errors of observation, will appear from the fact, that the *extreme difference* in the partial results with one of these needles, B (1), does not amount to 4′½, while with the other, (P), the extreme difference is only 2′. In fact, it so happens, that these very needles which differ most widely in their *mean* results are those in which the accordance of the *partial* results is most complete. Of the eight results obtained with needle P, there is one only which differs from the mean of the eight by a single minute; and yet the mean of all the observations with this needle differs by more than 20′ from the mean of any of the others, while its excess above the mean of the entire series amounts to 25′.

"These differences cannot be ascribed to any partial magnetism in the apparatus, for three of the needles (I, P and R) were of the same dimensions, and were used with the same circle, and yet their results, as we see, are widely discordant. We must seek then in the needles themselves the cause of these perplexing discrepancies, and we are forced to conclude that there may exist, even in the best needles, some source of constant error which remains uncorrected by the various reversals usually made; and that accordingly no repetition of observa-

tions with a needle so circumstanced can furnish even an approximation to the absolute dip."

I may add to the preceding remarks, that the discordances thus noticed far exceeded the limit of either diurnal or irregular fluctuations of the dip in England, as far at least as these phænomena have hitherto been the subject of observation.

An attentive consideration of the various sources of error to which dip observations might be liable,—of those which were already guarded against, and of those which still remained unprovided for,—induced the belief, that a considerable part at least of the discrepancies in question, and of similar discordances experienced elsewhere, were occasioned by the axle, on which the needle rests on the agate planes, not being perfectly cylindrical. Careful observers on the continent had already noticed defects of workmanship in this respect; and had been led thereby to have needles made, in which the axle, instead of being permanently fixed to the needle, was secured in its place merely by strong friction, and could be taken out, turned a portion of a circle on its own centre of rotation, and replaced; thus enabling the points of the circumference of the axle in contact with the supporting planes to be varied in successive trials. At Captain Ross's desire, Mr. Robinson undertook to have four needles of this description made, for one of which Mr. Frodsham, whose chronometers are so well known for their excellence, undertook to make the axle. On these needles being completed, they were tried each in four different positions of the axle,—that is to say, the axle being secured, an observation of the dip was made in the usual manner, and with the usual reversals:—the axle was then removed, turned on its own centre a portion of a circle, replaced, and the dip again observed:—in like manner, a third and fourth change was made in the position of the axle, and the dip observed at each. The process thus described was twice repeated with each needle. Of the four, Mr. Frodsham's axle proved the best; but the trial clearly manifested in all the imperfection which had been apprehended. The results with the needle furnished with Mr. Frodsham's axle are given in the subjoined table, where that needle is designated as No. 1.

With this experience Mr. Robinson undertook to replace the axles of the other three needles with three which should be the workmanship of his own hands. On these being tried, the discrepancies of each in the four positions were less than of any of the four axles in the former trial, but still amounted to several minutes. The results of the best of Mr. Robinson's axles have been selected for illustration, and are those of No. 2. in the subjoined table.

TABLE I.

Trials of the Axles of the under-mentioned Dipping Needles.

Needle 1. Frodsham's axle.			Needle 2. Robinson's axle.		
Position of the Axle.	Poles: α direct, β reversed	Mean Dip.	Position of the Axle	Poles α direct β reversed	Mean Dip
1	α 69° 34′·5	69° 11′·4	1	α 68° 42′·3	69° 22′·6
	β 68 48·2			β 70 02·9	
2	α 70 01·2	69 52·6	2	α 70 15·6	69 27·8
	β 69 44			β 68 10·1	
3	α 68 34	69 13·3	3	α 69 13·5	69 26·3
	β 69 52·6			β 69 39·1	
4	α 70 06·8	69 54·9	4	α 69 49·8	69 29·2
	β 69 43·1			β 69 08·6	
Mean of four positions of the Axle . . .		69 33·05	Mean of four positions of the Axle .		69 26·5
	Experiment	repeated.		Experiment	repeated
1	α 69 43·2	69° 18·9	1	α 69 54	69 18·5
	β 68 54·6			β 68 43	
2	α 70 11·2	70 01·5	2	α 68 53·1	69 29·5
	β 69 51·9			β 70 05·8	
3	α 69 05·4	69 26·3	3	α 69 50·8	69 23
	β 69 47·1			β 68 55·2	
4	α 69 42·9	69 48·9	4	α 69 02·6	69 20·6
	β 69 54·9			β 69 50·6	
Mean of four positions of the Axle		69 38·9	Mean of four positions of the Axle		69 25·15

The observations having been made in a house, the dip observed is not the true dip in London. This is immaterial, as the object of the experiment was solely the agreement or otherwise of the results in the different positions of the axle.

Had the axles been perfect, the same dip should of course have been given in all positions of the axle: we perceive, however, that the differences in the one needle amount to above 40′, and in the other from 7′ to 11′. The results of these experiments fully impressed Mr. Robinson with the necessity of employing more effectual means for ensuring a true figure to the axles of dipping needles; and in several which he has since made, and which have been carefully examined, he has proved successful.

Having exhibited the discrepancies of the earlier needles, it may be satisfactory to show the improvement in some of the later ones; and for that purpose the following observations are given with needles which were afterwards employed in the general observations of this report. The axles of these needles, being made

to revolve, were successively tried in four positions, which were, as nearly as could be guessed, a quarter of the circumference apart; had they been precisely so, the needle must have rested on the same points of the axle, in the 1st and 3rd positions, and in the 2d and 4th, (as the poles are reversed in each observation), and the results in those positions should have been the same; but as this can have been only approximately done, each position may be considered as bringing a different set of bearings into play. The observations were made as before, in Mr. Robinson's house, and have therefore no reference to the true dip.

TABLE II.

Trials of the Axles of the undermentioned Dipping Needles. London, June and July, 1838.

Positions of the Axis.	1st Pair		2nd Pair		3rd Pair	
	R. 4.	R. 5.	R. 6.	R. 7.	W. 1	W. 2.
1	69° 44′·9	69° 43′·5	69° 39′·8	69° 43′·1	69° 48′·4	69° 48′·9
2	69 43·8	69 39·9	69 40·4	69 40·8	69 50·4	69 46·0
3	69 38·1	69 46·2	69 41·4	69 47·0	69 49·5	69 46·7
4	69 43·4	69 44·8	69 36·8	69 38·8	69 53·5	69 47·8
Mean..	69 42·5	69 43·6	69 40·0	69 42·4	69 50·5	69 47·4

In all these six needles a great improvement was manifested. The greatest difference occurring in any two positions of the axle of any one of the six needles is 8′, including of course accidental errors of all kinds.

The imperfection of the axle is a source of error, from the effects of which, if it exists, the results can scarcely be freed by any mode of conducting the observation; at least, without going through the very tedious operation of observing round the circumference of the axle on every occasion. When accuracy is desired, therefore, only such needles should be employed, as have been ascertained by preliminary trial to be nearly free from this defect. Needles with revolving axles are easily tried. Those of the ordinary description, in which the axle is permanently fixed, may be examined by observing the angle of inclination shown by the needle when the circle is turned in different azimuths from that of the magnetic meridian, and by computing the dip by means of appropriate formulæ, from the angles shown in the different azimuths. If the axle is perfect the dips so computed should all accord. In the azimuths intermediate between the magnetic meridian and its normal plane, the needle rests successively on all points of the axle comprised in a portion of the quadrant equivalent to the complement of the dip;

and the corresponding points of the other three quadrants become in turns the points of support in the customary processes of the reversals of the poles and circle. If this operation is gone through at any part of the earth on or near the line of no dip, the whole of the quadrant is thereby subjected to examination. In such situations, consequently, this method affords the means of examining the whole circumference of the axle; and in all other localities, as much of the circumference as amounts to four times the complement of the dip. Whatever portion in the latter cases remains unprovided for, may be tested by converting the needle, temporarily, into one on Mayer's principle. This can easily be done by the application of a little wax; the quantity of which may be varied at pleasure, so as to correspond with the weights of different sizes, by which, in Mayer's method, the angles of inclination, from which the dip is computed, are varied in successive observations. By one or other of these processes the true dip at any station can be obtained from any and every inclination of the needle, and every part of the circumference of the axle can consequently be tested.

In what has been said, it has been presumed that there is no magnetism in the circle itself, as, should such exist, it would certainly become the source of discordance in the results derived from different azimuths, or from different weights, independently of any defect in the axle; and so far, therefore, the agreement of the results in such trials (should they be found to agree) indicates with great probability the freedom of the circle from magnetism as well as the goodness of the axle. But Mr. Lloyd has employed and has described in a subsequent part of this report an independent and much more delicate mode of examination for magnetism in the circle.

The customary provision of *two* needles for each apparatus does not alone afford security against the errors which may be occasioned by either of the defects to which I have now alluded. In respect to the axle, if the results of the two needles are accordant, it is thus far satisfactory, that it certainly is not probable that both needles should have accidentally exactly the same imperfection; but if they differ, the observer has no guide as to which is to be preferred; whilst their mean result cannot usually be more than an approximation to the true dip, for it is also improbable that the two needles should have an exactly equal amount of error in opposite directions. As a means of detecting magnetism in the limb, two needles are of no more avail than one; because both are directed to the same point of the circle when observed with at the same station, and, if a disturbing influence exists, both will be subjected to the same error. If, however, one of the needles is temporarily fitted on Mayer's
principle, and the dip is obtained in successive

arcs differing very widely from each other, and distributed generally round the whole circle,—and if the results in such case accord well with each other, and with those of the unweighted needle,—it may be concluded that there is no disturbing influence in the limb.

Those who are desirous of making accurate observations, should regard the preliminary examination of the axle and limb of the apparatus they employ as an indispensable precaution. When these points have been satisfactorily examined, and the instrument is found correct, the natural magnetic direction, both in regard to azimuth and inclination, is the most advantageous for the observation of the dip. It is in the preliminary examination, that the method devised by Mayer, and that of varied azimuths, are chiefly valuable*.

It may now be satisfactory to exhibit the observations that have been made at Westbourne Green in the years 1837 and 1838 with different circles and approved needles. (Table III.) The greater part of these instruments were made by Mr. Robinson since his attention has been particularly directed to the circumstances above noticed; and those who will take the trouble to compare their performance with that of the several needles employed by Captain Ross at the same station in 1835, will have an opportunity of judging how great an improvement has been effected in our English dipping needles since that period. Of the two other instruments not made by Robinson, one was made by Gambey for Captain Fitz Roy, of the Royal Navy, and kindly placed by that officer at my disposal, to be employed in the observations in this report. The excellence of the dipping needles of this artist is too well known to need any comment in this place. The other instrument was made by Mr. Thomas Jordan of Falmouth, the artist employed by Mr. Fox to make the dip apparatus on the construction which he has devised, and which is described in a paper in the 3rd vol. of the "Annals of Electricity, &c." Mr. Fox's needles do not rest on a cylindrical axle supported by planes, but the axle is terminated by exceedingly fine and short cylindrical pivots, which

* The needle employed by Sir Everard Home in the observations published in the last volume of the Phil. Trans. 1838, Part 2, appears, by its results at the Athenæum at Plymouth, and at Ham, near London, to have given dips exceeding the truth by about half a degree. It is probable that a careful examination would trace this error to imperfection in the axle; and in such case errors of a contrary character would exist when the axle should rest on some other points of its circumference, and may have influenced the determinations at some of Sir Everard's foreign stations. By the methods pointed out in this report, a table of [illegible]

work in jeweled holes. By means of the "deflectors" which make a part of Mr. Fox's apparatus, the dip may be deduced from readings at various parts of the circle, and there is therefore the same opportunity of discovering errors caused by magnetism of the circle, or by imperfection in the bearings of the axle, as the azimuthal and Mayer's methods furnish in needles of the ordinary construction: the jewel-plate itself is also made to revolve, so that the resting-places of the axle in the jewels may be changed at pleasure. The performance of these needles sufficiently indicates the great care bestowed on their workmanship. As the different observations in Table III. include an interval of eighteen months, they have been rendered more strictly comparable by the addition of a column, in which they are reduced to the common epoch of the 1st January, 1838, by applying a proportional part of the annual rate of decrease of the dip in London at this time, which, from reasons that will be assigned hereafter, is considered to be 2′·4.

TABLE III.

Observations of Dip at Westbourne Green in 1837 and 1838, with approved Needles.

Artist.	Needle.	Observer.	Date.	Observed Dip.	Deduced Dip, Jan. 1, 1838.
Robinson .	P 1.	Phillips	May 30, 1837	69 22·5′	69° 21·1′
.. .	P 2	.... .	. ....	69 17·9	69 16·5
Gambey ...	G 1.	Ross.	Aug. 10, 1837	69 20·6	69 19·7
......	G 2.	......	......	69 19·8	69 18·9
Robinson ..	P 1.	Phillips	March 28, 1838	69 19·5	69 20·1
.....	P 2.	......	......	69 17·0	69 17·6
Jordan		Fox	June 8, 1838	69 17·0	69 18·0
Robinson ..	W 1.	Ross	June 16, 1838	69 16·2	69 17·3
......	W 2.	.... .	.. ...	69 12·9	69 14·0
......	R 4.	......	July 6, 1838	69 13·7	69 14·9
.. ...	R 5.	......	......	69 12·8	69 14·0
.....	R 6.	... ..	July 7, 1838	69 14·0	69 15·2
... .	R 7.	......	......	69 16·4	69 17·6
......	R 4.	......	Dec. 4, 1838	69 15·5	69 17·7
......	R 5.	......	......	69 12·8	69 15·0
......	R 6.	......	Dec. 10, 1838	69 15·9	69 18·2
......	R 7.	......	......	69 14·4	69 16·7
				Mean......	69 17·2

The subjoined tables, IV., V., VI., VII., VIII., exhibit in detail the azimuthal examinations which have been made of some of the instruments employed in the observations contained in this report; it has appeared the more desirable to give these tables,

Table IV. contains observations made at Tortington on th 17th of October, 1837, with Captain Fitz Roy's Gambey, an its needle No. 2. The dip is here successively deduced fro the angles of inclination observed in azimuths 90° apart fro each other. In such case, $\cot^2 \delta = \cot^2 i + \cot^2 i'$, δ being th true dip, and i and i' the angles of inclination in any azimuth 90° apart. In the first example in the table, i is the angle o inclination shown by the needle when the plane of the circle i removed 10° from the magnetic meridian; that is, when it is i the direction of N. 10° E., and S. 10° W; i therefore include and is the mean of observation with the poles direct and re versed, and with the index of the azimuth circle at 10° and 190° i' is in like manner a mean of the angles of inclination with th poles direct and reversed, when the index of the circle is a (10 + 90° =) 100°, and at (100 + 180° =) 280°: here $\cot^2 i + \cot^2 i' = \cot^2 69° \, 13'{\cdot}5 + \cot^2 86° \, 15'{\cdot}2 = \cot^2 \delta$; whence $\delta = 68° \, 36'{\cdot}6$ In the next deduction, the values of i and i' are obtained wit the index of the azimuth circle at 20° and 200°, (20 + 90° =) 11 and 290°, and so forth.

TABLE IV.

Tortington, Oct. 17, 1837, with Captain Fitz Roy's Gambey Needle 2. Observer, Major Sabine.

Azimuth.	Poles direct.	Poles reversed.	Mean.	Dip deduced.	Azimuth.	Poles direct.	Poles reversed.	Mean.	Dip deduced
°	° ′	° ′	° ′	° ′	°	° ′	° ′	° ′	° ′
10	69 15	69 05	69 13·5	68 56·64	50	76 06·5	75 50·7	76 00·9	68 56·
190	69 07	69 22			230	75 53·2	76 13		
100	86 12	86 28·7	86 15·2		140	73 34·2	73 49·2	73 38	
280	86 25	85 55			320	73 44·3	73 24·3		
20	70 04·5	69 50	70 02·7	68 55·64	60	79 06·7	78 48	79 01·6	68 56·
200	70 00·2	70 16			240	78 53·6	79 16·6		
110	82 36·2	82 50·7	82 39		150	71 34	71 50·2	71 35·7	
290	82 45·5	82 23·5			330	71 39·2	71 19·3		
30	71 39	71 16·2	71 30·4	68 56·26	70	82 31·7	82 14	82 25·2	68 55·
210	71 26·2	71 40·6			250	82 18·8	82 36·5		
120	79 09·7	79 20	79 12		160	70 08·7	70 22·3	70 07	
300	79 20·5	78 58			340	70 07·5	69 52·5		
40	73 37·7	73 18·3	73 30	68 56·26	80	86 11	85 44	86 01·6	68 54·
220	73 23·8	73 40·2			260	85 56	86 14·7		
130	76 07	76 23·2	76 10·4		170	69 09·2	69 30·5	69 13·9	
310	76 16·5	75 55			350	69 13	69 02·8		
					0	68 55·6	68 46	[illegible]	[illegible]

The mean of the nine results in the preceding table is 68° 56′·1. Each angle is a mean of four readings. Total number of readings, 272.

Table V. (in two parts) contains observations made by Captain Edward Johnson, R.N., F.R.S., and myself, with the same circle and needle, in the Regent's Park, London, on the 15th and 16th November, 1837. In this case, the reversal of the needle on its supports was made a part of the series, in addition to the reversals in the last table; thus the values of i and i' are each the mean of eight angles instead of four.

Table V.

Observations with Capt. Fitz Roy's Gambey, Regent's Park, London.

Observer, Captain Johnson. 1837.

Nov	Azimuth	Poles Direct, Needle Direct.	Poles Direct, Needle Reversed	Poles Reversed, Needle Direct	Poles Reversed, Needle Reversed.	Means.		Dip Deduced
		° ′	° ′	° ′	° ′	° ′	° ′	° ′
15.	0	69 19·25	69 14·25	69 16·75	69 35·25	69 21·37	69 25·25	69 25·25
	180	69 19·75	69 24·25	69 43·75	69 26·75	69 29·13		
15 & 16	15	70 0	69 49·5	69 50	70 04·5	69 56	70 01	69 22·08
	195	69 58	70 07·5	70 13·5	69 59	70 03		
	105	84 15·5	84 36	84 37·5	84 28·5	84 29·4	84 25·5	
	285	84 28	84 15	84 13·5	84 30·5	84 21·7		
	30	72 04	71 45·5	71 48·5	72 08	71 56·5	71 59·95	69 25·30
	210	71 54	72 05	72 14·5	72 00	72 03·4		
	120	79 15	79 34·5	79 33·5	79 14·5	79 24·4	79 20·8	
	300	79 26	79 09·5	79 06	79 27	79 17·1		
	45	75 12·5	74 58·5	74 57	75 16·25	75 06·1	75 08·7	69 24·30
	225	75 07	75 16	75 19·5	75 03	75 11·4		
	135	75 03·5	75 11	75 17·5	75 06·5	75 09·6	75 05·4	
	315	75 05	75 00·5	74 52·5	75 07	75 01·2		
	60	79 29	79 10	79 13	79 38	79 22·5	79 25·3	69 24·20
	240	79 26	79 34	79 37	79 15·5	79 28·1		
	150	71 55	72 04	72 12·5	71 52·5	72 01	71 56·3	
	330	71 56·5	71 45	71 46·5	71 58·5	71 51·6		
	75	84 22·5	84 21·5	84 18	84 36·5	84 27·4	84 28·9	69 22·50
	255	84 28	84 31	84 41·5	84 21	84 30·4		
	165	69 56·5	70 01·5	70 17	69 57	70 03·75	70 00·6	
	345	70 03·5	69 51·5	69 48	70 06·5	69 57·4		
16	180	69 17·5	69 29·7	69 41·5	69 07·75	69 24·11	69 22·3	69 22·30
	0	69 20·5	69 13·5	69 10	69 38	69 20·5		
						General Mean.		69 [illegible] 7

Table V.

Observations with Captain Fitz Roy's Gambey, in the Regent's Park, London.

Observer, Major Sabine. 1837.

Nov.	Azimuth.	Poles Direct Needle. Direct.	Poles Direct Needle. Reversed.	Poles Reversed Needle Direct.	Poles Reversed Needle Reversed.	Means.		Dip Deduced
15.	° 0	° ′ 69 20·8	° ′ 69 14·5	° ′ 69 15·7	° ′ 69 35	° ′ 69 21·5	° ′ 69 24·75	° ′ 69 24·75
	180	69 17·5	69 25·2	69 43	69 26·3	69 28·0		
15 & 16	15	70 03	69 40	69 45	70 05·5	69 55·6	70 01·2	69 22·61
	195	69 59·5	70 10	70 19	69 59	70 06·9		
	105	84 18	84 40·5	84 38·5	84 23	84 30	84 27	
	285	84 32	84 15·5	84 16	84 33	84 24·1		
	30	72 02	71 48	71 46·5	72 11	71 56·1	72 00·5	69 25·72
	210	71 54	72 06	72 12·5	72 07	72 04·9		
	120	79 13	79 35·5	79 32·5	79 23	79 26	79 20·8	
	300	79 24·5	79 12·5	79 02·5	79 23	79 15·6		
	45	75 07·5	74 59·5	74 58·5	75 21·25	75 06·7	75 08·3	69 24·47
	225	75 06	75 14	75 15	75 01·5	75 09·9		
	135	75 04·5	75 10	75 20	75 08·5	75 10·75	75 06·25	
	315	75 07·5	74 57·5	74 54	75 08	75 01·75		
	60	79 24	79 13·5	79 16	79 42	79 23·9	79 26·2	69 24·17
	240	79 24·5	79 36	79 37·5	79 16	79 28·5		
	150	71 50·5	72 03·5	72 14·5	71 54·5	72 00·75	71 55·75	
	330	71 57·5	71 44	71 45	71 56·5	71 50·75		
	75	84 37	84 22·5	84 19·7	84 37·5	84 29·2	84 30·3	69 23·08
	255	84 28·5	84 32	84 36	84 29	84 31·4		
	165	69 55·5	70 05·5	70 18	69 57	70 04	70 00·9	
	345	70 06·5	69 49	69 50·5	70 05	69 57·75		
16.	180	69 17	69 33	69 42·7	69 09	69 25·44	69 24	69 24
	0	69 21	69 13·2	69 12·5	69 43·5	69 22·56		
						General Mean.		69 24·11

Each of the numbers, both in Captain Johnson's and Major Sabine's observations, is a mean of the readings of the two ends of the needle. In the azimuths 0 and 180° each number is also a mean of two distinct observations, between which the needle was raised from its supports, and lowered afresh. At all the other azimuths one such observation by each of the observers was considered sufficient. The total number of readings is 224 by each observer.

Table VI

Observations with Gambey's Circle and Needle 2 at Dover; by Major Sabine. 1837.

Azimuth	Face of Needle to face of Circle				Remarks
	Poles Direct	Poles Reversed	Mean	Dip	
30° and 210°	71° 31′ 1	71° 33′	71° 32′	68 53 2	On the side of the hill above Archcliff Fort on the 2nd November
120 and 300	79 04 5	78 59 1	79 01 8		
60 and 240	79 07 1	79 09 8	79 08 5	68 52 9	
150 and 330	71 26 4	71 29 6	71 28		
0 and 180	68 48 8	68 54 8	68 51 8	68 51 8	
Mean				68 52 6	
	Face of Needle Reversed				
30 and 210	71 30 5	71 32 5	71 31 5	68 51 3	Beneath Shakspeare's Cliff on the 7th November
120 and 300	79 02 2	78 54 5	78 58 4		
60 and 240	79 14 5	79 13	79 13 7	68 52 2	
150 and 330	75 21 7	71 27	71 24 4		
0 and 180	68 52 7	68 54·6	68 53 6	68 53 6	
Mean . .	. .	.	. ...	68 52 4	

Table VII. contains observations by Professor Phillips, with a six-inch circle by Robinson, and its needle 1 The inclination of the needle ($\imath$) was observed with the circle in different azimuths (θ), and the dip computed from the inclination found in each azimuth by the formula $\cot \delta = \cot \imath \sec \theta$.

Table VII.

Observations of the Dip with Mr Phillips's Circle and Needle 1.

York, Sept 13, 1838			Helmsley, Sept 14, 1838			Malton, Sept 15, 1838		
Azimuth θ	Inclination $\imath$	Dip δ	Azimuth θ	Inclination $\imath$	Dip δ	Azimuth. θ	Inclination $\imath$	Dip. δ
00°	70° 50′ 6	70° 50′ 6	00°	70° 57′ 4	70° 57′ 4	00°	70° 51′ 7	70° 51′ 7
10	71 08 2	70 51 5	10	71 14 2	70 58 0	10	71 08 1	70 52
20	71 53 7	70 49 1	20	72 01 7	70 56 0	20	71 54	70 49·3
30	73 16 9	70 52·5	30	73 21 5	70 57 5	30	73 15 5	70 50 6
40	75 04 6	70 48 5	40	75 13	70 59 5	40	75 03	70 47
50	77 22 5	70 47 3	50	77 31 4	71 00 0	50	77 26·1	70 52 5
60	80 07 9	70 49 9	60	80 16	71 04 0	60	80 05·9	70 45 4
Mean Dip .		70 48 6	Mean Dip		70 58 9	Mean Dip		70 49·8

Table VIII. contains observations by Captain James Ross, with a six-inch circle by Robinson, and its needles R. 4. and R. 6., at Jordan Hill, in September 1838. The dip is here computed by the formula, $\cot^2\delta = \cot^2 i + \cot^2 i'$; and in the final column the dip observed in the ordinary manner, *i. e.* in the azimuths 0 and 180°, is inserted for comparison.

Table VIII.

Observations with Robinson's Needles R. 4. and R. 6., Jordan Hill, September 1838.

Observer, Captain James C. Ross.

Needle R. 4.

Azimuth	Poles α.		Poles β.		Means.	Dip Deduced	Azimuth. 0 & 180°
	Needle Direct	Needle Reversed	Needle Direct.	Needle Reversed.			
	° ′	° ′	° ′	° ′	° ′	° ′	° ′
60	81 4·6	81 10·4	81 3·5	81 18·5	81 4·1	72 21·6	72 22·2
240	81 4·2	81 3·6	81 3·2	80 44·5			
150	74 31·6	74 27·8	74 19·8	74 32·3	74 32·1		
330	74 47 2	74 29·9	74 40·8	74 28			

Needle R. 6.

Azimuth	Poles α. Needle Direct	Poles α. Needle Reversed	Poles β. Needle Direct.	Poles β. Needle Reversed.	Means.	Dip Deduced	Azimuth. 0 & 180°
45	77 10·7	77 5 5	77 26	77 26	77 16·7	72 19·4	72 17·7
225	75 5·8	77 24	77 22·8	77 13			
135	77 18·5	77 3	77 25·1	77 21·9	77 19·5		
315	77 15·7	77 23·3	77 21·7	77 22·9			

Annual Alteration of the Dip.

The observations of dip included in this report, extend over an interval of four years and upwards. To reduce these to a common epoch, we require to know the amount of the change which the dip undergoes from year to year. In the Reports on the Magnetic Observations in Ireland and Scotland, an annual decrease of three minutes was provisionally assumed; but we must now endeavour to assign the amount with somewhat greater precision.

In the 21st volume of the Annalen der Physik, M. Hansteen has assembled all the most trustworthy observations of the dip in London, Paris, Berlin, and Geneva during the present century, and the latter part of the last; and has computed from them the most probable amount of the annual decrease of the dip at each of those stations, corresponding to every tenth year, from 1780 to 1830. As the results of this investigation have not been published, I believe, in this country, I have subjoined a table in which they are exhibited.

TABLE IX.

Annual Decrease of Dip

Year	Paris	London	Berlin	Geneva	Mean
1780	6′ 75	4′ 90	5′ 26	5′ 04	5′ 49
1790	5 92	4 57	4 71	4 71	4 98
1800	5 11	4 21	4 15	4 38	4 46
1810	4 29	3 88	3 58	4 05	3 95
1820	3 47	3 55	3 02	3 72	3 44
1830	2 64	3 22	2 46	3 39	2 93

The differences which appear in the progression and rate of the annual decrease at the four stations in this table, are probably attributable in far greater proportion to incidental errors in the observations, than to the actual existence of such differences. We may consequently regard the final column, or the mean of the results at the four stations, as affording, in all probability, a more satisfactory conclusion in regard to the rate of change at any one of the stations than is drawn from the observations at that station only

We may proceed to examine how far this rate of decrease corresponds with the most recent observations made in Britain In August 1821, I made a series of more than usually careful observations on the amount of the dip in the Regent's Park in London, employing for that purpose a needle on Mayer's principle, with weights of different magnitudes to obviate the liability to any constant instrumental error, and continuing the observations during several days in order that the general result might approximate the more nearly to the true mean dip at the period. These observations were published in the Phil. Trans for 1822, Art I, their final result being a dip of 70° 02′ 9, corresponding to the middle of the month of August 1821 To compare with this, we have the observations made in London, at different times and in different localities, by the contributors to this report It is proper that we should employ for the present purpose only those observations which give entirely independent determinations; viz those only which are complete in all the requisite positions of the needle and circle, including the reversal of the poles, and which need no correction for instrumental defects Of such observations we have those at Westbourne Green, already given in Table III, those in the Regent's Park, contained in Table V, an observation by Mr. Fox, in May 1838, in a field west of Maiden

Lane, and one of mine, on the 13th of October, 1838, in the gardens of the Palace at Kew. These are collected in the following table.

TABLE X.

Observations of the Dip in London in 1837 and 1838, with approved Needles.

Date	Observer	Dip observed.	Place of Observation
1837.			
May 30	Phillips	69° 20′·2	Westbourne Green.
Aug 10.	Ross	69 20·2	Westbourne Green.
Nov. 15. & 17	Johnson & Sabine	69 23·9 *	Regent's Park.
1838.			
March 28.	Phillips	69 18·2	Westbourne Green.
May 22.	Fox	69 19 0	Maiden Lane.
June 8.	Fox	69 17·0	Westbourne Green.
June 16.	Ross	69 14 5	Westbourne Green.
July 6.	Ross	69 18·3	Westbourne Green
July 7.	Ross	69 15·2	Westbourne Green.
Oct. 13.	Sabine	69 16·5	Kew Gardens.
Dec 4.	Ross	69 14·1	Westbourne Green.
Dec 10.	Ross	69 15·2	Westbourne Green.
Mean {corresponding to the beginning of May 1838.}		69 17·3	

We have therefore 70° 02′·9 in August 1821, and 69° 17·3 in May 1838; or a diminution of 45′·6 in 16·7 years, equivalent to a mean annual decrease of 2′·73, corresponding to the middle of the interval, or to the beginning of the year 1830. The

* This is the mean of fourteen results, extremely accordant with each other, obtained in different azimuths, (see Table V) It will be remarked that it is decidedly the highest of the results from which the mean dip in London has been derived. The observations with the same instrument at Kew, as well as every comparison between this and other instruments, give reason to believe that the high dip in the Regent's Park, in November 1837, is not attributable to any instrumental error It may then have arisen either from the dip on those days being actually greater by three or four minutes than its general average, or from some local disturbing influence. The locality is the same in which the observations in 1821 were made, and the result in question may on that account appear more strictly comparable with them; but though the locality is the same, it is not one in which we can feel confident that no change may have occurred in regard to magnetic influence. The Regent's Park is certainly not so eligible a situation *now* for magnetic experiments as it was in 1821. These considerations have induced me to derive the London Dip in 1838 for the purpose in the text, from the mean of the observations and localities in Table X, rather than from those in the Regent's Park alone; and not to give to the latter result that additional weight in comparison with the others to which it would seem entitled as derived from observations in so many azimuths.

mean rate for the same year in M Hansteen's table is 2′ 93, which must be regarded as a satisfactory accordance, the difference being less than exists between the rate for that year at any one of the stations in M Hansteen's table, and the mean of the four stations We may infer from the accordance, therefore, that both these numbers, 2′ 93 and 2′·73, are extremely near the truth, and I have employed that which results from our own observations, namely, 2′ 73 corresponding to 1830. Following the progression in M Hansteen's table, the rate of decrease would become 2′·4 in 1836, which is the middle period of the observations contained in this report In the reductions to a common epoch, 2′ 4 has consequently been employed as the mean annual decrease of the dip in the British Islands between 1834 and 1838. In the absence of any certain knowledge in regard to the unequal distribution of the yearly decrease in the different months of the year, I have regarded it as taking place in the uniform proportion of 0′ 2 per month

In a recent communication to the Royal Irish Academy, Mr Lloyd has stated the result of thirty-nine observations of the dip in Dublin between October 1833 and August 1836, which, combined by the method of least squares, give 2′ 38 for the most probable rate of the annual diminution of the dip in Dublin during that period. This result, though drawn from so limited a period, is in remarkable accordance with the deduction from the observations in London, and furnishes a strong presumption that the rate thus found is applicable both to England and Ireland In regard to Scotland, no observations have as yet been made, I believe, with this particular object The general aspect of the observations in Scotland, at different dates, contained in this report, would certainly indicate a less annual change than has been deduced from the observations in England and Ireland, and in every instance in Scotland where observations have been made at the same station and at different periods, either by the same or different observers, the evidence is of the same nature,—the results would be brought into better accord if a smaller rate of decrease were adopted In the case of the Shetland Islands, the dip observed by Captain Ross at Lerwick in August 1838, 73° 45′, compared with that observed by Sir Edward Parry and myself in June and November 1818, 74° 22′, makes a decrease of 37′ in twenty years, or a yearly diminution of 1′ 85, corresponding to the mean epoch of 1828 The observations of 1818 and of 1838 were made in the same garden The identity of the spot,—the length of the interval,—and the repetition of the observations on different days on both occasions,—all give weight to this comparison, and strengthen

the inference, that the rate of annual decrease is less in Scotland than in England. Still, in the absence of more positive data, I have not chosen to make any assumption; and have employed the one rate for the whole of the British Islands. The general result in Scotland, *i. e.* the mass of observations taken collectively, is independent of the amount of this reduction, the sum of the + and − reductions to the mean epoch of the 1st of January, 1837, being very nearly the same. the effect of a less rate of diminution than that adopted would be to increase the dips deduced from the observations in 1836, and to decrease those deduced from the observations in 1837 and 1838; and thus to give a rather more consistent aspect to the whole, without sensibly altering the resulting isoclinal lines.

No correction has been applied for the different hours of the day at which the several observations were made; but the hour is in almost all instances recorded. Professor Phillips had devoted several days of observation to the investigation of the regular horary variations of the dip, and had obtained results remarkably consistent, considering that they were derived from observations with the ordinary dipping needle*; but the recent invention of instruments specially adapted to this object, renders it probable that the phenomena of the periodical changes will be shortly determined with an accuracy hitherto unattainable: in the mean time, it has appeared preferable to apply no correction on this account. It may be proper to remind the reader, that the most perfect correction in this respect would still leave unremedied the influence of the irregular fluctuations, which there is great reason to believe frequently exceed in amount, and occasionally counteract the ordinary periodical movements.

I proceed now to give in detail the observations which comprise the first division of this report; namely, those of the Dip in England, Scotland, and Ireland. It will be convenient to separate these into three sections, commencing with those of England; and it may here be remarked generally, that all the latitudes and longitudes in this Report are taken from the maps published by the Society for Diffusing Useful Knowledge. The longitudes *east* of Greenwich are distinguished by the negative sign prefixed.

* Mr Phillips's observations at St Clairs and York, in the summer of 1837, from 7 a.m. to 11 p m., appear to indicate a morning maximum of dip at 9 or 10 a.m., an evening minimum about 8, with a difference of above 5 minutes, the mean dip recurring about 3 p.m , and the line passing through the three points nearly parabolic.

SECTION I.—ENGLAND.

Mr. Fox's observations.—I have arranged in the following table the observations of the dip in England with which I have been furnished by Mr. Fox, and have added thereto the columns containing the latitudes and longitudes, and the dips reduced to the mean epoch of the 1st January, 1837. The results in 1835 were obtained with a six-inch apparatus; those in 1837 with a seven-inch, and those in 1838 with a four-inch apparatus; all the instruments being those of Mr. Fox's construction, and made by Mr. Thomas Jordan of Falmouth.

TABLE XI.

Mr. Fox's Observations of the Dip in England.

Station.	Date.	Hour.	Lat.	Long.	Dip observed.	Dip deduced, 1 Jan. 1837.	Place of Observation.
Holyhead	Sept. 1, '35	5½ A.M.*	53° 19′	4° 37′	71° 04′	71° 00′·8	Hotel Garden.
Bangor	Sept. 1, '35	10 A.M.	53 14	4 06	71 02	70 58·8	Hotel Garden
Carnarvon	Sept. 1, '35	3 P.M.	53 09	4 14	70 58	70 54·8	Hotel Garden.
Llanberris	Sept. 1, '35	6½ P.M.	53 07	4 08	70 57	70 53·8	Foot of Snowdon
Capelcurig.........	Sept. 3, '35	7½ A.M.	53 06	3 58	70 48	70 44·8	Hotel Garden.
Malvern	Sept. 5, '35	8½ A.M. 10½ A.M. 5 P.M.	52 07	2 19	70 11	70 07·8	Mean of 3 Stations.
Ross..	Sept. 8, '35	9½ A.M. 1 P.M.	51 55	2 35	70 00	69 56·8	Hotel Garden
Neath	Sept. 11, '35	2 P.M.	51 40	3 46	69 57	69 53·9	Glenvellyn Cottage.
Chepstow	Sept. 9, '35	8 A.M.	51 38	2 40	69 48	69 44·8	Hotel Garden.
Belsay	Aug. 25, '37	11 A.M.	55 07	1 53	71 17	71 18·6	
Skiddaw	Sept. 7, '37	1½ P.M.	54 40	3 09	71 15	71 16·6	The Summit
Keswick	Sept. 7, '37	8 A.M.	54 39	3 08	71 14	71 15·0	Near the Lake.
Shull	Aug. 19, '37	7½ A.M.	54 43	2 00	71 14	71 15·5	
Grassmere	Sept. 9, '37	8¼ A.M.	54 27	3 01	71 13	71 14·6	Behind the Inn.
Darlington	Aug. 21, '37	7½ A.M.	54 32	1 33	71 07	71 08·5	Polham Hill
Garstang........	Sept. 12, '37	11½ A.M.	53 54	2 47	70 59	71 00·7	Inn Garden.
Studley Park ..	Aug. 14, '37	1 P.M.	54 08	1 34	70 56	70 57·5	
Bussco Bridge	Sept. 12, '37	4 P.M.	53 39	2 50	70 45	70 46·7	
Near Liverpool	Sept. 23, '37	8 A.M.	53 25	2 55	70 44	70 45·7	At the Dingle.
Liverpool	Sept. 19, '37	0½ P.M.	53 25	2 58	70 39	70 40·7	Botanic Garden.
Matlock	Aug. 9, '37	10 A.M.	53 08	1 32	70 19	70 20·5	Bath Hotel Garden.
London	May 22, '38 June 8, '38	5 P.M. 1 P.M.	51 32	0 11	69 19 69 17	69 21·4	Near Maiden Lane. Westbourne Green.
Tooting	June 14, '38	8 A.M.	51 26	0 10	69 14·5	69 17	The Grove.
Falmouth..	July 31, '38	6 P.M.	50 09	5 06	69 13·5	69 17·3	Mr Fox's Garden.
Eastwick Park	June 16, '38	8¼ A.M.	51 17	0 19	69 09	69 11·5	
Eastbourne... .	June 20, '38	3 P.M.	50 47	−0 16	68 45	68 48·5	Grounds of D. Gilbert, Esq.
Combe-House .	July 2, '38	8¼ A.M.	51 31	2 34	69 32	69 35·6	
St Mary's, Scilly	Aug 31, '38	8 A.M.	49 55	6 17	69 26	69 30	
Trescow, Scilly	Aug. 31, '38	1 P.M.	49 57	6 18	69 27	69 31	

We have in this table the dip observed at twenty-nine stations, of which the central geographical position is 52° 45′ N. and 2° 49′ W. If we desire to express the general result of this series of observations, as to the position of the isoclinal lines, their mean direction, and their mean distance apart in the district of country which the observations comprise, in the manner proposed by Mr. Lloyd in the discussion of the Irish Magnetic lines (British Association Reports, vol. iv. pages 151—156);—and if we call δ the dip at the central position, u the angle which the isoclinal line, passing through the central position, makes with the meridian; r a co-efficient determining the rate of increase of the dip in the normal direction; a and b co-ordinates of distance in longitude and latitude of the several stations from the central position, expressed in geographical miles and if we make $r \cos u = x$, and $r \sin u = y$;—we may proceed to form equations of condition of the form described in the report on the magnetical observations in Scotland (British Association Reports, vol. v. pages 4 and 5), and to combine them by the method of least squares. It is unnecessary to encumber this report with the details of calculation; and it is sufficient to state, that from the three final equations we obtain $x = + \cdot 2633$; $y = - \cdot 5154$; $u = - 62° \,'41$ (the direction being from N. 62° ′41 E. to S. 62° ′41 W.); $r = 0' \cdot 580$, being the rate of increase of dip in each geographical mile measured in the direction perpendicular to the isoclinal line; and $\delta = 70° \,'22 \cdot 9$ the dip at the central position at the mean epoch of the observations, namely, January 1, 1837.

Mr. Lloyd's Observations.—These observations were made with a $4\frac{1}{2}$ inch circle by Robinson, and two needles, designated as L 3 and L 4, employed also for determinations of the intensity. These needles consequently had not their poles reversed; and the dips observed with them require corrections to produce the true dip. These corrections have been ascertained by Mr. Lloyd, as stated in a subsequent part of this Report, to be as follows:

Needle L 3. + 5′·3
Needle L 4. +13′·4

These corrections have been applied in the following table, in the column entitled Corrected Dip.

Table XII.

Station	1836	Hour.	Needle	Observed Dip	Corrected Dip	Place of Observation.
London ...	Apr. 19	1 P.M.	L 3	69° 25′·0	69° 30′·3	Westbourne Green.
	Apr. 19	1 28 P.M.	L 4	69 07·8	69 21·2	
	Apr. 21.	2 37 P.M.	L 4	69 13·8	69 27·2	
	Apr. 21.	2 58 P.M.	L 3	69 21·3	69 26·6	
Shrewsbury	Apr. 25.	2 45 P.M.	L 4	70 05·1	70 18·5	
		3 10 P.M.	L 3	70 31·4	70 36·7	
Holyhead .	Apr. 27.	11 15 A.M.	L 4	70 55·6	71 09	Rocky Height near the Town.
		11 30 A.M.	L 3	71 03·0	71 08·3	
		0 40 P.M.	L 4	70 53·4	71 06·8	
		1 7 P.M.	L 3	71 04·0	71 09·3	
		1 20 P.M.	L 3	71 04·7	71 10	
Birkenhead	Aug 8	9 0 A.M.	L 4	70 36·2	70 49·6	Garden of the Hotel.
		9 35 A.M.	L 3	70 43·6	70 48·9	
		10 0 A.M.	L 3	70 43·0	70 48·3	
		10 20 A.M.	L 4	70 36·2	70 49·6	
Shrewsbury	Aug. 9	11 15 A.M.	L 4	70 17·1	70 30·5	Fields near the River.
		11 40 A.M.	L 3	70 22·1	70 27·4	
		0 7 P.M.	L 3	70 19·4	70 24·7	
		0 20 P.M.	L 4	10 14 6	70 28	
Hereford...	Aug. 10	10 50 A.M.	L 4	69 52·0	70 05·4	In a Plantation one mile from the Town
		11 20 A.M.	L 3	70 02·6	70 07·9	
		11 45 A.M.	L 4	69 53·2	70 06·6	
		0 5 P.M.	L 3	70 03·2	70 08·5	
Chepstow ..	Aug. 12	11 40 A.M.	L 4	69 32·6	69 46	Near the Castle.
		0 10 P.M.	L 3	69 44·5	69 49·8	
Salisbury...	Aug. 13	10 45 A.M.	L 4	69 09·0	69 22·4	Field near the Town.
		11 10 A.M.	L 3	69 18·5	69 23·8	
Ryde	Aug. 15	11 30 A.M.	L 4	68 57·1	69 10·5	Near the Sea.
		0 0	L 3	69 01·6	69 06·9	¼ of a mile East of the Town
	Aug. 16	0 20 P.M.	L 4	68 40·5	68 53·9	
		0 45 P.M.	L 3	68 53·8	68 59·1	
Clifton.. .	Aug 20	11 15 A.M.	L 4	69 27·0	69 40·4	Durdon Downs
		11 40 A.M.	L 3	69 39·8	69 45·1	
		0 5 P.M.	L 4	69 30·8	69 44·2	
		0 30 P.M.	L 3	69 35·4	68 40·7	
Ryde	Sept. 24	11 45 A.M.	L 4	68 49·4	69 02·8	
		0 15 P.M.	L 3	68 50·5	68 55·8	
		0 40 P.M.	L 4	68 47·8	69 01·2	
		1 10 P.M.	L 3	68 55·4	69 00·7	
Brighton...	Sept. 27	11 15 A.M.	L 3	68 43·8	68 49·1	Downs N. E. of the Town.
		11 40 A.M.	L 4	68 36·9	68 50·3	
		0 0	L 3	68 44·0	68 49·3	
		0 30 P.M.	L 4	68 36·8	68 50·2	
London ...	Oct. 4	0 45 P.M.	L 3	69 17·4	69 22·7	
		1 20 P.M.	L 4	69 02·6	69 16	
		1 40 P.M.	L 3	69 12·0	69 17·3	
		2 0 P.M.	L 4	69 06·8	69 20·2	
Cambridge	Oct. 8	0 20 P.M.	L 3	69 37·0	69 42·3	Grounds of Trinity College.
		0 40 P.M.	L 4	69 31·0	69 44·4	
		1 10 P.M.	L 3	69 30·5	69 35·8	
		1 35 P.M.	L 4	69 30·1	69 43·5	
Lynn	Oct. 10	0 55 P.M.	L 3	69 51·0	69 56·3	Pleasure-ground near the Town.
		1 25 P.M.	L 4	69 38·6	69 52	
		2 0 P.M.	L 3	69 48·5	69 53·8	
		2 20 P.M.	L 4	69 37·5	69 50·9	
Matlock ...	Oct. 12	0 15 P.M.	L 3	70 27·2	70 32·5	Field N. of the Town.
		0 25 P.M.	L 3	70 25·5	70 30·8	
		0 35 P.M.	L 4	70 13·4	70 26·8	
		0 50 P.M.	L 4	70 13·4	70 26·8	
Manchester	Oct. 14	10 50 A.M.	L 3	70 43·5	70 48·8	Field near the Town.
		11 05 A.M.	L 3	70 44·2	70 49·5	
		11 20 A.M.	L 1	70 34·4	70 47·8	

Table XII. contains the latitudes and longitudes of Mr. Lloyd's stations, and the mean dip at each station the number of distinct comparisons are, at London 2, Shrewsbury 2, Ryde 2; at each of the other places, 1. in the subsequent calculation, these numbers are taken as the weights.

Table XII.

Station	Lat	Long	Dip	Station	Lat	Long	Dip
	° ′	° ′	° ′		° ′	° ′	° ′
Holyhead	53 19	4 37	71 08 5	Chepstow	51 38	2 41	69 47 9
Birkenhead	53 24	3 00	70 49 1	Clifton	51 27	2 36	69 42 6
Manchester	53 28	2 14	70 47 7	Cambridge	52 13	−0 07	69 41 5
Matlock	53 08	1 35	70 29 2	Salisbury	51 04	1 47	69 23 1
Shrewsbury	52 42	2 46	70 27 6	London	51 32	0 11	69 22 7
Hereford	52 04	2 44	70 07 1	Ryde	50 44	1 10	69 01 3
Lynn	52 45	−0 25	69 53 2	Brighton	50 50	0 08	68 49 7

If we combine these fourteen results by the method of least squares, we obtain the following values. $x=+\cdot 2899$; $y=-5753$; $u=-63^\circ\ 15'$; $r=0\ 644$; and $\delta=69^\circ\ 54'$ at the mean geographical position, of which the latitude is $52^\circ\ 4'$, and the longitude $1^\circ\ 43'$ W

Professor Phillips's Observations.—These were made with a six-inch circle and two needles, by Robinson At some of the stations marked †, the reversal of the poles was intentionally omitted, from a desire to determine small local differences, under circumstances as similar as possible, the needles being very nearly equilibrated. The table shows which of the observations were thus incomplete; and the comparison of the results at the other stations, before and after the reversal of the poles, shows the probable small limit of error which may have been involved by the omission With the poles direct, and also with the poles reversed, the mean of four positions was taken, being eight in all, the needle was always inverted on its supports, as well as the circle turned in azimuth. four readings of each end of the needle were generally taken in each position.

TABLE XIII.

Professor Phillips's Observations of the Dip.

Station	Date.	Hour.	Needle.	Poles, α direct, β reversed	Mean.	Mean Dip	Place of Observation
	1837			° ′	° ′		
London....	May 30	2 P.M.	1	α 69 22·9			
				β 69 22·1	69 22·5		
			2	α 69 16·6		° ′ 69 20·2	Westbourne Green
				β 69 19·1	69 17·8		
†Doncaster ...	June 2	6½ P.M.	1	α 70 25·6	70 25·6		
			2	α 70 27·6	70 27·6	70 30·1	Garden of the New Angel Inn.
	— 3	7 A.M.	1	α 70 34·3	70 34·3		
			2	α 70 33·1	70 33·1		
York	— 3	2½ P.M.	1	α 70 48·6			
				β 70 47·3	70 47·9		
			2	α 70 52·1			
				β 70 45·3	70 48·7		
		7 P.M.	1	α 70 48·4			
				β 70 44·5	70 46·4		
			2	α 70 45·8			
				β 70 45·3	70 45·5		
	— 5	9 A.M.	1	α 70 50·3			
				β 70 51·6	70 50·9		
			2	α 70 50·7		70 48·6	Stone in Professor Phillips's garden, and stone in the grounds of the Philosophical Society.
				β 70 51·9	70 51·3		
		11 A.M.	1	α 70 51·2			
				β 70 50·5	70 50·8		
			2	α 70 51			
				β 70 51·5	70 51·2		
		7½ P.M.	1	α 70 45·1			
				β 70 46	70 45·5		
			2	α 70 47·5			
				β 70 49	70 48·2		
Thursk	— 6	3 P.M.	1	α 71 00			
				β 70 59·1	70 59·5		
			2	α 71 00·2		70 59·2	Garden of the Fleece Inn.
				β 70 57·5	70 58·8		
Osmotherley .	— 6	8 P.M.	1	α 71 1·6			
				β 71 2·3	71 1·9		
			2	α 71 5·7		71 3·2	Garden of the Inn.
				β 71 3·3	71 4·5		
Hambleton End	— 7	9 A.M.	1	α 71 3·6			
				β 71 7·4	71 5·5		
			2	α 71 2·1		71 4·0	Top of the mountain.
				β 71 3·1	71 2·6		
Whitby	— 9	7½ A.M.	1	α 70 59·4			
				β 70 57·4	70 58·4		
			2	α 70 56·7		70 57·9	In Mr. Ripley's garden.
				β 70 57·9	70 57·3		
Flamborough	— 11	8 P.M.	1	α 70 33·8			
				β 70 40·7	70 37·2		
			2	α 70 36		70 36·9	Garden of the Seabird's Inn
				β 70 37	70 36·5		
Scarborough .	— 13	1 P.M.	1	α 70 40·4			
				β 70 42·5	70 41·4		
			2	α 70 42·3		70 41·9	In Dr. Murray's garden.
				β 70 41·9	70 42·1		

Station.	Date.	Hour.	Needle.	Poles α direct, β reversed	Mean.	Mean Dip	Place of Observation
	1837.			° ′	° ′		
York	June 14	11½ A M		α 70 47·4			
	— 14	11½ A.M.	1	β 70 47·5	70 47·4		
			2	α 70 47 5			
				β 70 48 6	70 48·0		
	— 15	4 P M	1	α 70 46 1			
				β 70 45·2	70 45·6		
			2	α 70 46 5		70° 46′ 5	Stone in Professor Phillips's garden, and stone in the grounds of the Philosophical Society
				β 70 49 3	70 47 9		
		8 P.M.	1	α 70 44·9			
				β 70 44	70 44 4		
			2	α 70 41·5			
				β 70 49	70 45 2		
Sheffield......	— 17	7 P M.	1	α 70 27·5			
				β 70 31 3	70 29·4		
			2	α 70 27 2		70 29·6	Botanic Garden.
				β 70 32 6	70 29 9		
Birmingham .	July 3	2½ P M.	1	α 70 9 5			
				β 70 9 1	70 9 3		
			2	α 70 7·7			
				β 70 13·5	70 10·6		
	— 8	6¼ P.M.	1	α 70 4·5		70 07 2	Mr. Wreford's garden at Edgbaston.
				β 70 6·6	70 5·5		
			2	α 70 1·5			
				β 70 5 6	70 3 5		
St Clairs near Ryde	— 19	8¼ A M	1	α 68 59 1			
				β 68 58 3	68 58 7		
			2	α 68 55 3			
				β 69 0·7	68 58		
	— 20	11 A.M.	1	α 69 1·2			
				β 69 1·2	69 1·2		
			2	α 68 56 8			
				β 69 3·7	69 0 2		
	— 21	2¼ P M	1	α 68 59·7		69 1·2	In the garden
				β 68 55 7	68 57 7		
			2	α 68 58 8			
				β 68 59 5	68 59 1		
	— 22	8¼ A.M	1	α 69 6 6			
				β 69 9·7	69 8·1		
			2	α 69 3 5			
				β 69 9 9	69 6 7		
York*.	Aug 1	7 A.M	1	α 70 48·3			
				β 70 53·6	70 50·9		
			2	α 70 32 5			
				β 71 5 3	70 48 9		
		9¼ A M.	1	α 70 53 5			
				β 70 54·5	70 54		
			2	α 70 35			
				β 71 7·1	70 51·0		
		3 P.M.	1	α 70 52·3		70 51·1	Stone in Professor Phillips's garden, and stone in the grounds of the Philosophical Society.
				β 70 51 7	70 52		
			2	α 70 33 2			
				β 71 7 6	70 50·4		
	— 3	7½ A.M.	1	α 70 49 1			
				β 70 53 2	70 51·1		
			2	α 70 49 7			
				β 70 51·1	70 50 4		

* Needle 2 was subjected to an alteration by Robinson, after the observations of

Station	Date.	Hour	Needle.	Poles α direct, β reversed	Mean.	Mean Dip.	Place of Observation
	1837			° ′	° ′		
Calderstone..	Aug. 12	10¾ A.M.	1	α 70 44·6			
				β 70 45·6	70 45 1		
			2	α 70 42 6			
				β 70 49·5	70 46·0	70 43·5	In the grounds of J. N. Walker, Esq.
		1½ P.M.	1	α 70 37 6			
				β 70 42·2	70 39 9		
			2	α 70 44			
				β 70 41·6	70 42·8		
Douglas, Isle of Man ...	— 17	3 P.M.	1	α 71 20 5			
				β 71 22·7	71 21·6		
			2	α 71 23		71 22 2	Castle Mona Inn garden.
				β 71 22·5	71 22 7		
†Castleton ..	— 18	8½ A.M.	1	β 71 23·3	71 23 3	71 22·55	In a field adjoining the Inn yard.
			2	β 71 21 8	71 21·8		
†Peel Town..	— 18	2 P.M.	1	β 71 22·6	71 22·6		
			2	β 71 24·7	71 24·7	71 24·0	Near the Inn and on the Castle Hill.
		8½ P.M.	1	β 71 24	71 24		
			2	β 71 24·6	71 24·6		
†Birkenhead.	— 26	1 P.M.	1	β 70 40 6	70 40·6		
			2	β 70 39 8	70 39 8	70 39 4	Inn garden.
		2½ P.M.	1	α 70 38 8	70 38 8		
			2	α 70 38 6	70 38·6		
Coed Dhu...	Sept. 20	Noon	1	α 70 40·7			
				β 70 40·2	70 40·4		
			2	α 70 41·3		70 40·9	Grounds of J. Taylor, Esq.
				β 70 41·5	70 41·4		
†Bowness ...	— 25	9 A.M.	1	β 71 18·9	71 18·9	71 18·4	Ullocks Inn, the terrace
			2	β 71 17·9	71 17·9		
†Coniston ...	— 25	1 P.M.	1	β 71 19·1	71 19·1	71 19 5	Field near the Inn garden.
			2	β 71 20	71 20		
†Patterdale .	— 27	1½ P.M.	1	β 71 19 9	71 19·9	71 19 6	Inn garden.
			2	β 71 19·4	71 19·4		
†Penrith ..	— 28	10¼ A.M.	1	β 71 23 7	71 23·7	71 23·4	In the Castle
			2	β 71 23 2	71 23 2		
†Carlisle	— 29	10½ A.M.	1	β 71 27 5	71 27·5	71 23·5	In the Castle
			2	β 71 20 5	71 20 5		
†Newcastle ..	— 30	7 A.M.	1	β 71 18 2	71 18·2	71 18·1	Fields west of the town.
			2	β 71 18	71 18		
	1838.						
London	Mar. 28	4½ P.M.	1	α 69 20 4			
				β 69 18·6	69 19 5		
			2	α 69 16·1		69 18·2	Westbourne Green.
				β 69 17·9	69 17		

Table XIV. contains the latitudes and longitudes of Mr. Phillips's stations, and the mean dip at each station reduced to the middle period of his observations, viz. the 1st of August, 1837.

the 22nd July, one of its arms having been originally longer than the other, so as sometimes to touch the circle. By shortening this arm the centre of gravity was slightly displaced, as is shown by the observation of Aug. 1. This was remedied by Mr. Phillips, the same evening, by grinding the other arm.

TABLE XIV.

Station.	Lat.	Long	Dip, 1 Aug. 1837.	Station	Lat.	Long	Dip, 1 Aug. 1837.
Carlisle	54° 51′	2° 54′	71° 28′·5	Whitby	54° 20′	0° 37′	70° 57′ 9
Peel Town.......	54 13	4 43	71 24	York....	53 58	1 05	70 48 4
Penrith	54 40	2 45	71 23·4	Calderstone..	53 23	2 53	70 43·5
Castleton.. . .	54 01	4 40	71 22 5	Scarborough .	51 17	0 21	70 41·8
Douglas	51 10	4 27	71 22·2	Coed Dhu . . .	53 11	3 12	70 40 9
Patterdale ..	54 32	2 56	71 19·6	Birkenhead.....	53 24	3 00	70 39 4
Coniston	54 22	3 05	71 19·5	Flamborough....	54 08	0 08	70 36 9
Bowness	54 22	2 55	71 18·4	Doncaster . . .	53 31	1 07	70 30·2
Newcastle. . .	54 58	1 38	71 18·1	Sheffield	53 22	1 31	70 29·6
Hambleton End	54 20	1 15	71 04	Birmingham. ...	52 28	1 53	70 07 2
Osmotherly... ..	54 22	1 18	71 03·2	London.. . ..	51 32	0 11	69 19 2
Thirsk.. . . .	54 14	1 21	70 59·2	St. Clairs.........	50 44	1 08	69 01·2

If we combine these twenty-four results by the method of least squares, we obtain the following values: $x = + \cdot 2658$ $y = - \cdot 5270$; $u = -63° \ 14'$; $r = 0' \cdot 590$; and $\delta = 70° \ 50' \cdot 1$ on the 1st of August, 1837, at the mean geographical position of which the Latitude is 53° 49′, and the Longitude 2° 08′.

Captain Ross's Observations.—In this extensive series no less than fifteen needles were employed. Those designated as R L 1 and R L 2, J, C, C 2, and C 3, were four-inch needles made by Robinson, and used in a circle made by Jones; the remainder R L 3, R L 4, R 3, R 4, R 5, R 6, R 7, W 1, and W 2, were six-inch needles, also by Robinson, and used in a circle by the same artist: R 4, R 5, R 6, R 7, W 1, and W 2, were fitted with revolving axles, and were found on trial to give accordant dips in different positions of the axle: each observation with them recorded in the following tables is a mean of the usual eight positions. For these needles, consequently, no corrections are applied, and it will be seen by the observations at Westbourne Green in June, July, and December, 1838, that all these needles gave very nearly the same dip when used under like circumstances of time and place. Their mean result at Westbourne Green has been employed by Captain Ross as a standard to furnish corrections for the other needles which he had employed previously, and on which he could not rely with equal confidence. Of these, R L 1, R L 2, R L 3, and R L 4, were used for the intensity as well as for the dip, and their poles, therefore, were not reversed. They were always used in pairs, and the correction determined for the mean result of R L 1 and R L 2 was + 3, and that for R L 3 and R L 4, + 16.

The remaining five needles were observed in the usual eight positions, but in consequence of imperfect workmanship required corrections, which, by comparison with the standard needles, were assigned as follows:

J = +7 C 2 = +5 R 3 = −8
C = +2 C 3 = +8

Wherever these needles are employed, the proper corrections are applied in a column in the table headed "corrected dip."

Table XV.

Captain J. C. Ross's Observations of the Dip.

Station.	Date	Hour.	Needle.	Poles α direct, β reversed	Mean	Corrected Dip	Mean Dip	Place of Observation
	1837.	h m						
London.......	Aug. 9	1 0 P.M.	J	α 69 31·8				
				β 68 46	69 8·9	69 15·9		
		3 0 P.M.	C	α 69 0·1				
				β 69 28	69 14 1	69 16 1		
			RL 1	69 27 3			69 16·05	Westbourne
			RL 2	68 59 1	69 13·2	69 16 2		Green, Har-
	— 10	1 10 P.M.	C 1	α 69 4·2				row Road.
				β 69 17·8	69 11	69 18		
Bushey	July 31	9 A.M.	C	α 68 58·4				
				β 69 41·8	69 19·9	69 21·9		
	— 30	1 P.M.	RL 1	69 35·1				
			RL 2	69 10·1	69 22·6	69 25·6	69 21 5	In the garden
	Aug 27	5 30 P.M	RL 2	69 7 6				of Bushey
	— 28	10 30 A.M.	RL 1	69 38·5	69 23	69 26		Lodge
Tortington....	— 15	5 30 A.M.	J	α 69 0·2				
				β 68 25·6	68 47·4	68 54·4		
		8 A.M.	C	α 68 39·8				
				β 69 11·1	68 55·4	68 57·4	68 55·9	In the garden
		Noon	RL 1	69 8·2				of Tortington
			RL 2	68 37·6	68 52·9	68 55·9		House, near
								Arundel.
Daventry......	Sept. 1	5 15 P.M.	RL 1	69 46·8				
	— 2	5 30 P.M.	RL 2	69 26·8	69 36 8	69 39·8		
		Noon	C	α 69 26·5				
				β 69 49·6	69 38·1	69 40·1	69 41·1	In the garden
		3 40 P.M	J	α 69 57·5				of the Wheat-
				β 69 15·6	69 36·5	69 43·5		sheaf Inn.
Birmingham..	— 4	Noon	RL 2	69 52				
		0 30 P.M.	RL 1	70 16	70 4	70 7		
		1 40	C	α 69 45·3				
				β 70 3·9	69 54·6	69 56·6	70 0·5	In a field half
		4 0	J	α 69 26				a mile south
				β 70 16	69 51	69 58		of St. Martin's
								Church.
Stafford	— 7	1 0 P.M.	RL 1	70 19·8				
		2 20	RL 2	69 57·6	70 8·7	70 11·7		In the garden
		4 0	C	α 69 54·6				of the New
				β 70 21·6	70 8·1	70 10·1	70 9·7	Inn. Old
	— 8	4 30 P.M.	J	α 70 24·2				Church, N.
				β 69 36·4	70 0·3	70 7·3		34° W.(true)
								half a mile.

Station	Date.	Hour	Needle.	Poles α direct, β reversed.	Mean	Corrected Dip.	Mean Dip	Place of Observation
	1837.	h m						
Birkenhead...	Sept. 18	3 30 P.M.	RL 2	70° 29′				
		4 45	RL 1	70 45·2	70° 37′·1	70° 40′ 1		
	— 19	9 50 A.M.	C	α 70 20·2				
				β 70 45·1	70 32 6	70 34 6	70° 36′·2	
		Noon	J	α 70 52·9				In the garden of the Hotel.
				β 70 0 7	70 26 8	70 33·8		
Douglas, (Isle of Man)	— 21	11 A.M.	RL 1	71 22·9				
		0 30 P.M.	RL 2	71 20 7	71 21·8	71 24·8		
		2 0 P.M.	C	α 71 2				
				β 71 30·2	71 16 1	71 18·1	71 20·3	In the grounds of Castle Mona.
		4 0 P.M.	J	α 71 35·7				
				β 70 46 3	71 11	71 18		
Birkenhead. .	Oct 11	Noon	C	α 70 16·3				
				β 70 46 9	70 31·6	70 33·6		
		1 30 P.M.	J	α 70 51 4				
				β 69 58·6	70 25	70 32	70 35 3	In the garden of the hotel.
		2 15 P.M.	RL 2	70 29				
		2 45 P.M.	RL 1	70 45·8	70 37·4	70 40·4		
Pwllheli	— 14	10 45 A.M.	C	α 70 22 1				
				β 70 38 7	70 30·4	70 32·4		
		1 P.M.	J	α 70 44 1				
				β 69 56·9	70 20 5	70 27 5	70 32 5	In the garden of the Four Crosses Inn.
		2 10 P.M.	RL 1	70 40				
		2 50 P.M.	RL 2	70 29	70 34·5	70 37·5		
Marlborough.	— 17	1 P.M.	C	α 69 9				
				β 69 33	69 21	69 23		
		2 30 P.M.	J	α 69 40·7				
				β 68 57 3	69 19	69 26	69 25·4	In the wood S. W of the Castle Inn.
		3 50 P.M.	RL 2	69 12 2				
		4 30	RL 1	69 36	69 24·2	69 27·1		
Clifton	— 21	3 50 P.M.	C	α 69 17 7				
				β 69 43·9	69 30 8	69 32 8		
	— 22	10 45 A.M.	J	α 69 50 3				
				β 69 1·3	69 25·8	69 32·8	69 34	In the garden of the Royal Gloucester Hotel.
		1 P.M.	RL 1	69 47·2				
		2 10 P.M.	RL 2	69 19 6	69 33·4	69 36·4		
Pembroke	— 25	2 30 P.M.	C 2	α 69 38 1				
				β 69 59 4	69 48 7	69 53·7		
	— 26	10 A.M.	J	α 70 9 6				
				β 69 26·8	69 48·2	69 55·2	69 55 9	In the garden of the Dragon Inn. Pembroke Church North (mag.) half a mile
		11 30 A.M.	RL 1	70 4·7				
		0 30 P.M.	RL 2	69 46·9	69 55·8	69 58·8		
Swansea	— 27	10 20 A.M.	C 2	α 69 5·3				
				β 70 9·9	69 37 6	69 42·6		
		0 30 P.M.	J	α 70 2 8				
				β 69 20 4	69 41·6	69 48·6	69 46·7	On the sands, about half a mile west of the Pier.
		1 40 P.M.	RL 1	69 56 4				
		2 20 P.M.	RL 2	69 35·2	69 45 8	69 48 8		

Station	Date.	Hour.	Needle.	Poles. α direct, β reversed	Mean.	Corrected Dip.	Mean Dip	Place of Observation
	1827	h m		° ′	° ′	° ′	° ′	
Ilfracombe	Nov 2	2 40 P.M	C 2	α 68 59·5				
				β 70 4·1	69 31·8	69 36·8		
	— 3	10 A.M.	C	α 69 4				
				β 70 4·6	69 34·3	69 39·3		
		11 50	J	α 69 51·2			69 36·9	In the garden of Rock Cottage, the residence of R. I. Coxhead, Esq
				β 69 7	69 29·1	69 36·1		
		1 20 P.M.	RL 1	69 50·9				
		2 30	RL 2	69 19·9	69 35·4	69 38·4		
Padstow.. ...	— 14	4 15 P.M	C 2	α 68 43·8				
				β 69 50	69 16·3	69 21·3		
	— 15	8 15 A M	RL 2	69 14·5				
		10 A M.	RL 1	69 36·7	69 25·6	69 28·6	69 25·1	On the sands opposite to the town.
		Noon	J	α 69 45·8				
				β 68 45	69 15·4	69 22·4		
Falmouth.....	— 18	10 A.M.	C 2	α 68 35				
				β 69 39·8	69 7·4	69 12·4		
		Noon	J	α 69 31·8				
				β 68 49·4	69 10·6	69 17·6	69 16·1	Pendennis Castle, bearing S 60° 17′ E. 2 or 3 miles Near the granite pillar at the north end of the meridian line
		1 45 P.M.	RL 2	69 2·1				
		2 30	RL 1	69 28·2	69 15·3	69 18·3		
Land's End .	— 21	0 30 P.M.	C 2	α 68 42·9				
				β 69 37·5	69 10·2	69 15·2		
		3 P.M.	J	α 69 37				
				β 68 48	69 12·5	69 19·5	69 18·5	In a field East of the First & Last Inn in England
	— 22	10 50 A.M.	RL 1	69 28·9				
		Noon	RL 2	69 7	69 17·9	69 20·9		
Plymouth .	— 28	2 10 P.M.	C 2	α 68 24·3				
				β 69 27·3	68 55·8	69 0·8		
		3 50 P.M.	J	α 69 20				
				β 68 36·8	68 58·4	69 5·4	69 6·2	In the garden of the Athenæum.
	— 29	11 30 A.M.	RL 1	69 22·2				
			RL 2	68 56·8	69 9·5	69 12·5		
Exeter.........	— 30	11 50 A.M.	C 2	α 68 37·1				
				β 69 45·7	69 11·4	69 16·4		
		1 40 P.M.	J	α 69 29·2				
				β 68 46·8	69 8	69 15	69 17·3	In a field, Exeter Cathedral, S.E. 1½ mile.
		3 P.M.	RL 1	69 30·3				
		3 45 P.M.	RL 2	69 4·6	69 17·4	69 20·4		
Weymouth ...	Dec. 2	2 20 P.M.	C 2	α 68 25·1				New Church S W by S. ¼ of a mile.
				β 69 29·8	68 57·5	69 2·5		
		4 P.M.	J	α 69 22·8				
				β 68 35·2	68 59	69 6	69 6·7	In the garden of the Bush Hotel.
	— 4	1 45 P.M.	RL 1	69 22·3				
		3 20	RL 2	68 54·7	69 8·5	69 11·5		
Salisbury......	— 5	0 20 P.M.	C 2	α 68 30·7				
				β 69 40·8	69 5·8	69 10·8		
		1 45	J	α 69 31·3				
				β 68 44·8	69 8	69 15	69 14·5	In a field, Salisbury Cathedral w.s.w. (mag.) 1¾ mile
		3 20	RL 2	69 1·5				
		4	RL 1	69 27·7	69 14·6	69 17·6		

Station	Date	Hour	Needle	Poles α direct, β reversed	Mean	Corrected Dip	Mean Dip	Place of Observatio
	1838	h m						
Southsea	Dec 8	11 20 A M	C 2	α 68° 21′ 4				
				β 69 25 8	68° 53′ 6	68° 58′ 6		
		1 20 P M	J	α 69 17				
				β 68 30 6	68 53 8	69 0 8	69° 0′ 4	In the gard
		2 40	RL 2	68 49 2				of the Bu
		3 30	RL 1	69 8 4	68 58 8	69 1 8		Hotel
Guildford .	— 12	2 P M	C 2	α 68 20 9				
				β 69 33 7	68 57 3	69 2 3		
		3 30 P M	J	α 69 20 1				
				β 68 36·9	68 58 5	69 5 5	69 5 1	In a field ¾ o
	— 13	11 A M	RL 2	68 54				mile east of t
			RL 1	69 14·8	69 4 4	69 7 4		Town Hall
London . .	Mar 6	1 P M	C 3	α 68 33 6				
				β 69 40 7	69 7 2	69 15 2		
	— 8	3 P M	C 3	α 68 33 3				
				β 69 41·6	69 7 5	69 15 5		
	April 10	1 50 P M	C 3	α 68 36·2				
				β 69 41 2	69 8 7	69 16 7		
		4 P M		α 68 36				
				β 69 29	69 2 5	69 10·5	69 14 7	Westbourne
	— 25	11 20 A M	R 3	α 69 56 1				Green, Ha
				β 68 49 8	69 22 9	69 14 9		row Road
		9 A M	RL 3	69 3 7				
			RL 4	68 54 5	68 59 1	69 15 1		
Margate. .	— 17	2 P M.	RL 3	68 48				
			RL 4	68 37 8	68 42·9	68 58·9		
		4 20 P M	R 3	α 69 32 8				
				β 68 32 2	69 2 5	68 54·5	68 57 2	In the gard
			C 3	α 68 18				of the Hope
				β 69 22 6	68 50 3	68 58·3		Anchor In
York ...	— 27	2 30 P M	RL 3	70 33 7				
			RL 4	70 23 5	70 28·6	70 44 6		
		4 10 P M	R 3	α 71 19 7				
				β 70 17	70 48·3	70 40·3		
	— 28	10 A.M.	R 3	α 71 27·8			70 45 2	In the garde
				β 70 25·2	70 56·5	70 48·5		of the Cro
		Noon	RL 3	70 34·5				Keys Hote
			RL 4	70 28·2	70 31 4	70 47 4		
Scarborough. .	May 1	1 40 P M	RL 3	70 32 5				
			RL 4	70 21·6	70 27·1	70 43·1		
		3 P.M.	R 3	α 71 28·3			70 43	In the garde
				β 70 13·2	70 50·8	70 42·8		of the Bu
Bridlington ...	— 3	9 15 A.M	RL 3	70 27·4				Inn, & clo
			RL 4	70 21 3	70 24·4	70 40·4		to the Ne
		11 10	R 3	α 71 24 8				Church
				β 70 5·4	70 45·1	70 37·1	70 38 8	In the garde
		7 P.M	RL 3	70 27·3				of the Sta
			RL 4	70 18·7	70 23	70 39		Inn

Station.	Date.	Hour.	Needle.	Poles α direct, β reversed.	Mean.	Corrected Dip	Mean Dip	Place of Observation.
	1838	h m						
Wadworth .	May 9	8 15 A.M.	R 3	α 71° 12'·3				
				β 69 58 0	70° 35' 0	70° 27' 0	70° 27'·5	In the grounds of Wadworth Hall the seat of R. J. Coulman, Esq.
		1 30 P.M.	RL 3	70 15 6				
			RL 4	70 7·2	70 11 4	70 27·4		
Nottingham...	— 12	Noon	R 3	α 71 3·0				
				β 69 45·7	70 24·7	70 16·7	69 16·3	Nottingham Church, S S E 1½ mile In a garden at Callington
		1 20 P.M.	RL 3	70 4·4				
			RL 4	69 55 4	69 59 9	69 15 9		
Louth	— 16	7 15 A.M.	R 3	α 71 12·2				
				β 69 46·2	70 29·2	70 21·2	70 19 5	Louth Church, S W 1 mile In the garden of the Woolpack Inn, River head
		9 30 A.M.	RL 3	70 4·9				
			RL 4	69 58 5	70 1 7	70 17 7		
Cromer	— 21	8 A.M.	R 3	α 70 34·8				
				β 69 18·7	69 56·8	69 48 8	69 16 1	In the garden of the Post office, close to the Church
		4 50 P.M.	RL 3	69 31·8				
			RL 4	69 22 8	69 27 3	69 43 3		
Lowestoffe . .	— 21	5 P.M.	R 3	α 70 11·1				
				β 68 57 4	69 35 0	69 27·0	69 29 2	In the grounds of the Suffolk Hotel.
		6 30 P.M.	RL 3	69 16·7				
			RL 4	69 12·1	69 14·4	69 30·4		
Harwich	— 28	8 20 P.M.	R 3	α 70 2				
				β 68 41·0	69 21·9	69 13·0		
		5 P.M.	RL 3	68 56·3				
			RL 4	69 3 5	68 59 9	69 15·9	69 15 4	In the grounds of the White Horse Inn, 2 miles west of Harwich.
	— 29	3 P.M.	RL 3	69 3 6				
			RL 4	68 57 2	69 0·4	69 16·4		
London.	June 16	1 15 P.M.	W 1	α 69 11·7				
				β 69 20·7	69 16·2			
		3 10	W 2	α 69 13·2				
				β 69 12·6	69 12 9			
	July 6	3 40 P.M.	R 4	α 69 16 1				
				β 69 11 5	69 13·7			
		7 P.M.	R 5	α 69 11		69 14·3	....	Westbourne Green, Harrow Road.
				β 69 11 6	69 12·8			
	— 7	Noon	R 6	α 69 10 1				
				β 69 17·9	69 14			
		2 10 P.M.	R 7	α 69 15·8				
				β 69 17	69 16·4			
	— 7	5 P.M.	RL 3	69 3·25				
	— 10	5 P.M.	RL 4	68 51 6	68 57·4	69 13·4		
Newcastle.. .	Aug 28	2 P.M.	R 6	α 71 10·4				
				β 71 16·7	71 13 6	....	71 13	In Mr. Newton's nursery grounds.
		4 P.M.	R 4	α 71 13·4				
				β 71 11·4	71 12·4	....		

Station	Date.	Hour.	Needle.	Poles α direct, β reversed	Mean.	Corrected Dip	Mean Dip	Place of Observation
	1838	h m						
Stonehouse .	Sept 1	2 45 P M	R 6	α 71° 17′·3				
				β 71 27 8	71° 22′ 3	... .	71 24 1	In the grounds of Stonehouse the seat of Col Sir Hew Dalrymple Ross, K.C.B
		4 15 P M	R 4	α 71 25 5				
				β 71 26 4	71 25 9	. ...		
London.	Dec. 4	10 45 A M	R 4	α 69 19 3				
				β 69 11 7	69 15 4	. . . .		
		0 30 P M.	R 5	α 69 8 3				
				β 69 17 4	69 12 8	....		
	— 10	Noon	R 6	α 69 12 3			69 14 67	Westbourne Green, Harrow Road
				β 69 19 6	69 15 9	....		
		2 P.M	R 7	α 69 13 9				
				β 69 14·9	69 14 4	....		

Table XVI. contains the latitudes and longitudes of Captain Ross's stations, with the mean dip at each station reduced to the 1st January, 1838, being the middle period of his observations

TABLE XVI.

Station	Lat	Long	Dip, 1 Jan 1838	Station	Lat.	Long.	Dip, 1 Jan 1838
Berwick .	55° 45′	2° 00′	71° 43′ 6	Ilfracombe ...	51° 12′	4° 06′	69° 36′ 5
Stonehouse .	54 55	2 44	71 25 7	Clifton..... ...	51 27	2 35	69 33 5
Douglas . .	54 10	4 28	71 19·6	Lowestoffe . .	52 28	−1 50	69 30 2
Newcastle	54 58	1 36	71 14 6	Marlborough .	51 25	1 43	69 24·9
York	53 57	1 06	70 46 0	Padstow ...	50 33	4 56	69 24·8
Scarborough	54 18	0 26	70 43·8	Bushy	51 38	0 22	69 23·6
Bridlington .	54 08	0 14	70 39 6	Land's End .	50 05	5 40	69 18 3
Birkenhead .	53 24	3 00	70 35 1	Exeter .	50 43	3 31	69 17·1
Pwllheli	52 55	4 23	70 32 0	Harwich	51 56	−1 13	69 16 4
Wadworth	53 28	1 07	70 26·6	Falmouth ..	50 09	5 06	69 15·8
Louth	53 19	0 0	70 18·6	London	51 32	0 11	69 15 4
Nottingham	52 57	1 08	70 15 4	Salisbury......	51 04	1 48	69 14 3
Stafford ...	52 48	2 06	70 09 0	Weymouth ...	50 37	2 27	69 06 5
Birmingham	52 28	1 53	69 59·7	Plymouth ...	50 23	4 07	69 06·0
Pembroke .	51 39	4 54	69 55 5	Guildford .	51 14	0 34	69 05 0
Cromer ...	52 56	−1 19	69 47 0	Southsea	50 48	0 58	69 00 2
Swansea ...	51 36	3 55	69 46 3	Margate	51 23	−1 23	68 57·9
Daventry ...	52 16	1 08	69 40 3	Tortington ...	50 50	0 34	68 55 0

If we combine the results at these thirty-six stations by the method of least squares, we obtain the following values: $x=+\cdot1974$; $y=-\cdot5114$; $u=-68°\ 54'$; $r=0'\cdot548$; and $\delta=69°\ 53'\cdot4$ at the mean geographical position of 52° 16′ N., and 1° 55′ W.

Major Sabine's Observations.—These observations were made at fifteen stations, with a 9½-inch circle, and two needles by Gambey, (Table XVII.); and at twelve stations with a circle of Nairne and Blunt of 11 inches in diameter, and a needle by Robinson, designated as S 2, (Table XVIII.)

Table XVII.

Major Sabine's Observations of the Dip with Captain Fitz Roy's Gambey.

Station	Date	Hour.	Needle	Poles α direct, β reversed.	Mean	Mean at the Station	Place of Observation
	1837						
ortington	Aug 15		1	α 69° 05′·1 β 68 54 8	68° 59′·95	68° 59′·6	In the grounds of William Leeves, Esq.
	— 15		2	α 68 56·1 β 69 02 1	68 59·3		
rkenhead	Sept 17		2	α 70 30·6 β 70 40·0	70 35·3	70 35 1	Garden of the Hotel.
	— 18		2	α 70 33 0 β 70 36 7	70 34 85		
berysthwith.	— 21	1 P M	2	α 70 20·6 β 70 26·1	70 23·35	70 23 5	On a hill north of the town
	— 21	2 P.M.	1	α 70 29·3 β 70 17 9	70 23·60		
unraven Castle .	— 26		1	α 69 52 1 β 69 39 9	69 46 0	69 45 7	In the grounds of the Earl of Dunraven.
	— 26		2	α 69 42 7 *β 69 48·6	69 45 65		
	— 28		2	α 69 42·6 β 69 48·2	69 45 4 *		
ortington	Oct. 16		2	α 68 51·8 β 68 56·6	68 54 2	68 54·8	In the grounds of William Leeves, Esq.
	—17 & 19		2	α 68 55 8 β 68 56 1	68 51·9 †		
over .	Nov 2	3½ P M	2	α 68 51 1 β 68 54 1	68 52 6 †	68 52·3	On, and beneath the Cliffs.
	— 7	1½ P.M	2	α 68 51·6 β 68 53 0	68 52 3 †		
	— 6	3 P.M.	1	α 68 54·0 β 68 49·8	68 51·9 †		
argate . . .	— 9		2	α 68 59·4 β 69 04 1	69 01·75		
	— 9	3½ P.M	1	α 69 09·9 β 69 00 8	69 05 3	69 02·9	Field behind Marine Terrace.
	— 11		2	α 69 04·1 β 69 03 7	69 02·54 ‡		
egent's Park, London .	—15 & 16		2	α β	69 23·9 §	69 23·8	In Mr. Jenkins's nursery grounds
	— 16		2	α 69 20·7 β 69 25·6	69 23·1 ‖		
	1838						
w Trenchard	July 19	Noon	2	α 69 13·6 β 69 22 2	69 17 9	69 19 0	In the grounds of W. Baring Gould, Esq.
	— 21	11 A.M.	2	α 69 17 9 β 69 22·5	69 20·2		

* Observed by Viscount Adare † Observed in various azimuths

‡ Observed in various azimuths.

§ In various azimuths Observers, Capt. Johnson, R.N., and Major Sabine.

‖ Observed by Capt. Johnson and Major Sabine.

Station	Date	Hour	Needle	Poles α direct, β reversed.	Mean	Mean at the Stations	Place of Observation
Falmouth . .	1838 July 25	9 A.M.	2	α 69° 09′ 1 β 69 14·7	69° 11′·9	69° 11′·9	In the grounds of Robert Were Fox, Esq.
Whitehaven.	Aug. 16	3 P.M.	2	α 71 06·8 β 71 15	71 10·9	71 10·9	Fields south of the town.
Newcastle ..	— 28	1½ P.M.	2	α 71 05·8 β 71 12·2	71 09·0	71 09·0	In Mr. Newton's nursery grounds.
Alnwick Castle	— 31	3 P.M.	2	α 71 22·9 β 71 22·2	71 22·6	71 22·6	In the grounds of the Duke of Northumberland.
Stonehouse .	Sept 2	5 P.M.	2	α 71 18·9 β 71 20·2	71 19·5	71 19·5	In the grounds of Colonel Sir Hew Dalrymple Ross, K.C.B.
Helensburg..	— 10	8½ A.M.	2	α 72 14·8 β 72 19·2	72 17·0	72 17·0	Fields near the Baths Hotel.
Jordan Hill . .	— 11	4½ P.M.	2	α 72 12·6 β 72 15·0	72 13·8	72 14·3	In the grounds of James Smith, Esq.
	— 13		2	α β	72 16·4*		
	— 13		2	α β	72 11·1*		
	— 14		2	α β	72 15·8*		
Worcester Park	Oct. 8	3 P.M.	2	α 69 03·9 β 69 09·6	69 06·7	69 06·75	In the grounds
Kew............	— 18	4½ P.M.	2	α 69 14·7 β 69 18·2	69 16·4	69 16·45	In the garden of the Palace.

* Observed by Archibald Smith, Esq.

Table XVIII

Major Sabine's Observations of Dip Needle, S 2.

Station	Date	Hour	Observed Dip	Mean	Corrected Dip	Place of Observation
	1837		° ′	° ′	° ′	
Tortington	May 17		69 05 8	69 08 25	68 58 65	In the grounds of William Leeves, Esq.
	— 29		69 04 8			
	Aug 5		69 15 7			
	— 5		69 06 7			
	July 27		69 26 3	69 28 15	69 18 55	Cloister Gardens
Westminster	— 27		69 29 8			
Shrewsbury	Sept 19	4 P M	70 34 2	70 34 45	79 24 85	Fields near the House of Industry
	— 19	5 P M	70 34 7			
Aberystwith	— 21	11¾ A M	70 35 6	70 35 5	70 25 9	Hill north of the town
	— 21	Noon	70 35 4			
Brecon	— 22	6 A M	70 12 6	70 12 75	70 03 15	Garden of the Hotel
	— 22	6¾ A M	70 12 9			
Merthyr	— 23	2 P M	70 15 2	70 13 5	70 03 9	Mr Thompson's grounds
	— 23	2½ P M	70 11 8			
Dunraven Castle	— 25	2½ P M	69 58 8	69 57 4	69 47 8	In the Castle-grounds
	— 25	3½ P M	69 57 9			
	Oct 3	0½ P M	69 55 5			
Tortington	— 15	4 P M	69 07 9	69 06 1	68 56 5	In the grounds of W Leeves, Esq.
	— 19	11¼ A M	69 04 3			
Dover . ..	Nov 2	2 P M	69 01 0	69 02 2	69 52 6	On and beneath the Cliffs.
	— 3	3 P M	69 03 8			
	— 6	2 P M	69 01 8			
Margate ..	— 9		69 08 2	69 10 4	69 00 8	Field behind Marine Terrace
	— 10	11 A M	69 12 6			
Regent's Park, London	— 14	1½ P M	69 26 9	69 29 72	69 20 12	Mr Jenkins' nursery-grounds
	— 14	2½ P M	69 27 2			
	— 14	3 P M	69 34 2			
	— 16	2½ P M	69 30 6			
	1838					
Jordan Hill	Sept 13	1 P M	72 22 0	72 21 4	72 11 8	In the grounds of J Smith, Esq
	— 13	2 P M	72 20 8			
Kew	Oct 13	1½ P M	69 24 0	69 24 0	69 14 4	In the gardens of the Palace

Note on the correction applied in Tables XVIII to the Dips observed with S 2 This needle being employed for the statical measurement of the variations of the intensity, the poles were not reversed in the dips obtained with it The "observed dips" in Table XVIII are consequently a mean of four positions only of the needle and circle; namely, of the circle in the azimuths 0° and 180°, and the same repeated with the needle reversed on its supports, both ends of the needle being read, and ten readings taken in each position There are twelve stations at which the dip was thus observed with S 2, at eight of these it was also observed with Gambey's instrument, in which the poles of the needle were

reversed, and the observation was consequently complete. At the other four stations Gambey's circle was not employed, and we have to deduce from the observations with S 2 the dips that would have been shown by a needle with the poles reversed. In the report of the Magnetic Observations in Scotland, (B. A. reports, vol vi page 98,) a correction for this purpose was derived from a comparison of results obtained at Limerick with S 2, and with a needle on Mayer's principle, used in a circle of Nairne and Blunt's; and we have here observations at eight other stations, furnishing materials for a similar comparison between the results of S 2, and of Gambey's instrument.

TABLE XIX.

Station	Dips observed: S 2	Dips observed: Mayer or Gambey	Error of S 2 = c	No of Sets: S 2 = n	No of Sets: Mayer or Gambey = n'	Weight $\frac{nn'}{n+n'}$ = N	$c \times N$
Limerick*	71° 14′ 63	71° 03′ 27	+11′ 36	10	5	3′ 3	37′ 49
Tortington (Aug)	69 11 2	68 59 6	+11 6	2	2	1 0	11 60
Aberysthwith	70 35 45	70 23 5	+11 95	2	2	1 0	11 95
Dunraven Castle	69 57 4	69 45 7	+11 7	3	3	1 5	17 55
Tortington (Oct)	69 06 1	68 54 8	+11 3	2	10	1 7	19 21
Dover	69 02 2	68 52 3	+ 9 9	3	5	1 9	18 81
Margate . .	69 10 4	69 02 9	+ 7 5	2	5	1 4	10 50
Regent's Park	69 29 7	69 23 8	+ 5 9	4	8	2 5	14 75
Jordan Hill	72 21 4	72 14 3	+ 7 1	2	4	1 3	9 23
Kew Gardens	69 24 0	69 16 45	+ 7 55	1	1	0 5	3 78
						16 1	154 87
Mean error of S 2 when the poles were not reversed						+9 6	

* The observations at Limerick with S 2 and Mayer's needle have been already detailed in the 6th Report of the British Association, page 98 As the comparison of their results is slightly affected by employing a different rate of annual decrease for the purpose of reducing the observations to a common epoch, they are stated afresh

Needle	Date	No of Sets	Observed Dip	January 1836	Mean, allowing weight for the number of Sets
S 2	July 1835	4	71° 16′ 93	71° 15′ 83	71° 14′ 63
—	Dec 1835	3	71 14 6	71 14 5	
—	Feb 1836	1	71 13 4	71 13 7	
—	May 1836	2	71 12 0	71 12 9	
Mayer	Nov 1833	2	71 11 7	71 06 6	71 03 27
—	May & June 1836	3	71 00 05	71 01 05	

A correction is therefore required of $-9' 6$ to all the dips observed with S 2. The application of this correction produces the final column in Table XVIII., entitled "Corrected Dips."

In Tables XVIII. and XIX., we have, then, the dip observed at fifteen stations with Gambey, and at four additional stations with S 2, making in all nineteen stations, which are inserted in the following table with their geographical positions, and the dips reduced to the mean epoch of the observations themselves, viz. the 1st January, 1838.

Table XX.

Station	Lat	Long	Dip, Jan 1 1838	Station	Lat	Long	Dip, Jan 1 1838
	° ′	° ′	° ′	Dunraven Castle	° ′ 51 28	° ′ 3 37	° ′ 69 45 0
Alnwick Castle	55 25	1 42	71 24 2	Regent's Park	51 34	0 10	69 23 5
Stonehouse	54 55	2 44	71 21 1	Lew Trenchard	50 40	4 10	69 20 3
Whitehaven	54 33	3 33	71 12 4	Kew Gardens	51 29	0 18	69 18 3
Newcastle	54 58	1 36	71 10 6	Westminster	51 31	0 07	69 17 5
Birkenhead	53 24	3 00	70 34 4	Falmouth	50 09	5 06	69 13 3
Shrewsbury	52 43	2 45	70 24 2	Worcester Park	51 23	0 17	69 08 6
Aberysthwith	52 24	4 05	70 22 8	Margate	51 23	−1 23	69 02 6
Merthyr	51 43	3 21	70 03 2	Tortington	50 50	0 34	68 55 5
Brecon	51 57	3 21	70 02 5	Dover	51 08	−1 19	68 51 9

Combining these by the method of least squares, we obtain the following values $x = +2305$, $y = -498$, $u = -65° 08'$, $r = 548$, and $\delta = 69° 56' 6$ at the mean geographical position, of which the latitude is $52° 18'$, and the longitude $1° 59'$.

If now we collect in one view the several values of u and r which have been thus obtained from the observations in England, we have as follows:

Table XXI

Observer	No of Stations	Mean Geographical Position		Values of	
		Lat	Long	u	r
		° ′	° ′	° ′	
Fox	29	52 45	2 49	−62 41	0 580
Lloyd	14	52 04	1 43	−63 15	0 644
Phillips	24	53 49	2 08	−63 14	0 590
Ross	36	52 16	1 55	−68 54	0 518
Sabine	19	52 18	1 59	−65 08	0 548

If we regard the several values of u and r as entitled to weight proportioned to the number of stations of which each is the representative, we obtain $-65° 05'$ and $0'·575$ as the mean values of u and r derived from the English series, corresponding to the central geographical position 52° 38′ N., and 2° 07′ W.

Section II.—Scotland.

Observations of Captain J. C. Ross.—These observations were made with Robinson's six-inch circle, and the needles R 4, R 5, R 6, and R 7, which have been already described.

Table XXII.

Captain J. C. Ross's Observations of the Dip, Scotland.

Station	Date.	Hour	Needle.	Poles α direct, β reversed.	Mean.	Mean Dip.	Place of Observation
	1838.			° ′	° ′	° ′	
Aberdeen ..	July 18.	4 P.M.	R 4	α 72 28·7			In a field one mile south of the city.
				β 72 25·7	72 27 2	72 27·6	
		1 P.M.	R 5	α 72 30			
				β 72 25·8	72 27·9		
Lerwick .. .	— 24	Noon	R 4	α 73 50 3			
				β 73 46 9	73 48 6		
		2 15 P.M.	R 5	α 73 43			
				β 73 41·6	73 42 3		
	— 25	Noon	R 6	α 73 41·8			
				β 73 46 4	73 44 1		Gardie House, Brassa Island.
	— 27	Noon	R 6	α 73 44 8		73 44·9	
				β 73 47·8	73 46 3		
		1 40 P.M.	R 4	α 73 48·9			
				β 73 43 3	73 46 1		
		3 P.M	R 5	α 73 43 2			
				β 73 41	73 42 1		

Station	Date	Hour	Needle	Poles α direct, β reversed	Mean	Mean Dip	Place of Observation
	1838	h m		° ′	° ′	° ′	
Kirkwall	July 31	1 0 P M	R 4	α 73 24 7			
				β 73 20 1	73 22 4		In the garden of the Caledonian Hotel
		2 40 P M	R 5	α 73 20 4			
				β 73 19 4	73 19 9	73 20 4	
		6 40 P M	R 6	α 73 16 9			
				β 73 21 1	73 19		
Wick . .	Aug. 8	Noon	R 4	α 73 27 6			
				β 73 18 3	73 22 9		In the garden of Rose-bank, the seat of Mr M'Leay
		2 P M	R 5	α 73 15 7			
				β 73 17 1	73 16 4	73 19 9	
		3 20 P M	R 6	α 73 17 5			
				β 73 23 3	73 20 4		
Golspie .	— 10	3 P M	R 6	α 73 0 3			Dunrobin Castle, E ¾ of a mile.—In the wood
				β 73 6 8	73 3 5		
		4 30 P M	R 4	α 73 7 3		73 4 3	
				β 73 3 2	73 5 2		
Inverness	— 13	3 P M	R 4	α 72 51 11			
				β 72 43 1	72 47 2		In the garden of the Caledonian Hotel
		4 15 P M	R 6	α 72 39 5			
				β 72 47 4	72 43 5	72 46 2	
	— 14	1 20 P M	R 6	α 72 46 1			
				β 72 49 6	72 47 8		
Culgruff ...	Sept 8	2 P M	R 4	α 71 36 4			In the grounds of Culgruff, the seat of George Clark Ross, Esq
				β 71 37 3	71 36 8		
		3 20 P M	R 6	α 71 31 8		71 35 7	
				β 71 37 6	71 31 7		
Jordan Hill .	— 13	1 15 P M	R 6	α 72 15 6			In the grounds of Jordan Hill, the seat of J Smith, Esq
				β 72 19 8	72 17 7		
	— 14	1 15 P M	R 4	α 72 21 6		72 20	
				β 72 22 8	72 22 2		
Berwick .	— 17	2 30 P M	R 6	α 71 35			In a garden half a mile north of the Scotch Gate
				β 71 41 6	71 38 3		
	— 18	Noon	R 4	α 71 46		71 41 9	
				β 71 45 1	71 45 6		
Dunkeld	— 20	2 30 P M	R 6	α 72 23 9			In a plantation of larch, Craigie Barns, S W by W three or four miles
				β 72 23 1	72 23 5		
		4 20 P M	R 4	α 72 26 8			
				β 72 22 8	72 24 8		
	— 21	Noon	R 5	α 72 22 2		72 23 1	
				β 72 22 2	72 22 2		
		2 40 P M	R 7	α 72 18 9			
				β 72 24 9	72 21 9		

Table XXIII contains the latitudes and longitudes of Captain Ross's Scottish stations, and the mean dip at each station at the dates shown in the preceding table The whole interval in which they are comprised is so short, that no reduction to a common epoch has been applied.

TABLE XXIII

Station	Lat	Long	Dip	Station	Lat	Long	Dip
	° ′	° ′	° ′		° ′	° ′	° ′
Lerwick	60 09	1 07	73 44 9	Aberdeen	57 09	2 05	72 27 6
Kirkwall	59 00	2 58	73 20 4	Dunkeld	56 35	3 33	72 23 1
Wick	58 24	3 05	73 19 9	Jordan Hill	55 54	4 21	72 20 0
Golspie	57 58	3 57	73 04 3	Berwick	55 45	2 00	71 41 9
Inverness	57 28	4 11	72 46 2	Culgruff	54 58	4 00	71 35 7

If we combine these ten results by the method of least squares, we obtain the following values $x = + 250$, $y = - 484$, $u = -62° 39'$; $r = 0' 545$, and $\delta = 72° 40' 8$ at the mean geographical position 57° 20′ N., and 3° 08′ W, and at the mean epoch August 18, 1838

Major Sabine's Observations—These observations were made at twenty-seven stations in the summer of 1836, with a circle by Nairne and Blunt, and the needle S 2 of Robinson The details have been already published in the 5th vol of the Reports of the British Association, and need not therefore be repeated in this place When that Report was published, the correction of S 2 was provisionally taken as —12′, it has since been more correctly ascertained to be −9′ 5 by a much more extensive series of comparative observations, (Table XIX) The subjoined table (XXIV) contains the latitudes and longitudes of the twenty-seven stations, and the dips, to which the new correction of —9′ 5 has been applied As the whole of these observations were comprised within an interval of six weeks, no reduction to a mean epoch has been thought necessary

Table XXIV.

Station	Lat	Long	Dip	Station	Lat	Long	Dip
	° ′	° ′	° ′		° ′	° ′	° ′
Tobermorie	56 38	6 01	73 07 6	Loch Ridan	55 57	5 10	72 16 6
Loch Scavig	57 14	6 07	73 05 2	Castle Duart	56 31	5 45	72 15 2
Loch Slapin	57 14	6 02	73 02 1	Braemar	57 01	3 25	72 14 1
Golspie	57 58	3 57	72 55 5	Kirkaldy	56 07	3 09	72 10 9
Inverness	57 27	4 11	72 46 4	Loch Gilphead	56 04	5 28	72 07 6
Artornish	56 33	5 48	72 42 8	Glasgow	55 51	4 14	72 01 6
Gordon Castle	57 37	3 09	72 40 8	Great Cumbray	55 48	4 52	72 01 1
Fort Augustus	57 08	4 40	72 40 3	Campbeltown	55 23	5 38	71 55 9
Rhynie	57 20	2 50	72 25 6	Blairgowrie	56 36	3 18	71 54 7
Loch Ranza	55 42	5 17	72 22 9	Edinburgh	55 57	3 11	71 50 3
Alford	57 13	2 45	72 21 9	Loch Ryan	54 55	4 59	71 43 3
Newport	56 25	2 55	72 17 4	Melrose	55 35	2 44	71 36 8
Glencoe	56 39	5 07	72 17 1	Dryburgh	55 34	2 39	71 33 6
Helensburg	56 0	4 41	72 16 7				

If we combine these twenty-seven results by the method of least squares, we obtain the following values $x = +\,337$, $y = -\,461$, $u = -53°\ 47'$; $r = 0\cdot571$, $\delta = 72°\ 18'\cdot7$ at the mean geographical position 56° 28′ N., and 4° 19′ W., and at the mean epoch September 1, 1836

Mr. Fox's Observations—These observations were made with Mr Jordan's 7-inch circle and needle, and are as follows

Table XXV.

Mr Fox's Observations of the Dip in Scotland.

Station	Date	Hour	Lat	Long	Dip	Place of Observation
	1837		° ′	° ′	° ′	
Melrose	Aug 26	11½ A M	55 35	2 44	71 38	East of the Abbey
Edinburgh	— 28	8 A M	55 57	3 11	71 47	Gard opposite Princes St
Edinburgh	— 28	6 P M	55 57	3 11	71 53	Botanic Garden.
Linlithgow	— 30	1½ P M	55 59	3 37	71 59	Near ruins of the Palace
Inverary	— 31	6 P M	56 15	5 04	72 7	In the Park
Loch Lomond	Sept 1	5 P M	56 13	4 40	72 15	Lakeside near Tarbet
Glasgow	— 4	4½ P M	55 51	4 14	72 5	Botanic Garden.
Moffat	— 6	8 A M	55 20	3 27	71 40	Near the Inn
Gretna Green	— 6	2 P M	55 01	3 04	71 29	Behind the Inn

The portion of country over which these observations extend is too limited to afford an advantageous combination for the deduction of the values of u and r; I have therefore combined them with my own twenty-seven results in Table XXIV., forming an united series of thirty-six stations towards the final deduction of the values of u and r in Scotland, Mr Fox's observations having been previously reduced to September 1836 From this combination we obtain the following values; $x = +\cdot 320$; $y = -\cdot 447$, $u = -54° \ 20'$; $r = 0\cdot 550$; $\delta = 72° \ 13\cdot 2$ at the mean geographical position 56° 18′ N., and 4° 10′ W.

If we collect in one view the values of u and r which have been thus obtained from the observations in Scotland, we have as follows

TABLE XXVI.

Observer	No of Station.	Mean Geographical Position.		Values of	
		Lat	Long	u	r.
Ross	10	57° 20′	3° 08′	−62° 30′	0 545
Sabine and Fox.. .	36	56 18	4 10	−54 20	0·550

Regarding the values of u and r as entitled to weight proportioned to the number of stations of which each is the representative, we obtain $u = -56° \ 06'$, and $r = 0 \ 549$, as the mean values derived from the observations in Scotland, and corresponding to the central geographical position of 56° 49′ N., and 3° 39′ W.

Section III.—Ireland.

(*This Section is by the Rev.* H. Lloyd.)

Before entering into the details connected with this division of our memoir, it will be necessary to make a few remarks upon the principles of the calculation which has been employed in deducing the position of the isoclinal lines from the scattered observations.

If z denote the dip (or intensity) at any station of observation; z_0 that at some *near* station, which is taken as the origin of co-ordinates; and x and y the actual distances (in geographical miles) between the stations, estimated on the parallel of latitude and on the meridian, respectively,—or the co-ordinates of position of the first station referred to the latter as an origin; then I have shown*, (Fifth Report, p. 151) that the relation of these quantities is expressed approximately by the equation

$$z - z_0 = \mathrm{M}x + \mathrm{N}y; \qquad (1)$$

in which M and N represent the increase of the dip (or intensity), corresponding to each geographical mile of distance in the two directions.

In employing this equation in the calculation of the isoclinal and isodynamic lines, I had taken one of the stations of observation—namely, Dublin—as the origin of co-ordinates. observation, therefore, gave the values of z and z_0, and the equations of condition thus obtained were combined, by the method of least squares, so as to give the most probable values of M and N. In a subsequent application of this method, (Sixth Report, p. 99) Major Sabine adopted a better course, and took an *arbitrary station*, with an *unknown* dip and intensity, as the origin. z_0 was thus unknown, as well as M and N; and the resulting equations gave not only the most probable values of the increase of the dip (or intensity) in the two directions, but likewise that of its absolute amount at some one station.

Let this latter quantity be denoted by L, i. e. let $z_0 = \mathrm{L}$ in the preceding equation; then each observation will furnish an equation of condition of the form

$$\mathrm{L} + \mathrm{M}x + \mathrm{N}y = z. \qquad (2)$$

Combining these equations by the method of least squares, we have the three following final equations:

* The notation here used is somewhat different from that employed in the Report. The variation can cause no embarrassment to the reader.

$$\begin{aligned} L\,\Sigma\,(w) + M\,\Sigma\,(w\,x) + N\,\Sigma\,(w\,y) &= \Sigma\,(w\,z), \\ L\,\Sigma\,(w\,x) + M\,\Sigma\,(w\,x^2) + N\,\Sigma\,(w\,x\,y) &= \Sigma\,(w\,x\,z), \\ L\,\Sigma\,(w\,y) + M\,\Sigma\,(w\,x\,y) + N\,\Sigma\,(w\,y^2) &= \Sigma\,(w\,y\,z), \end{aligned} \tag{3}$$

in which w denotes the *weight* of the determination, and the symbol Σ the *sum* of the n values of the quantities within the brackets, n being the number of separate determinations. From these equations, the most probable values of the three unknown quantities, L, M, N, are obtained by elimination.

If the point taken for the origin of the co-ordinates be that for which

$$\Sigma\,(w\,x) = 0, \quad \Sigma\,(w\,y) = 0\,,$$

or be, as it were, the *centre of gravity* of the stations, the final equations are reduced to

$$\begin{aligned} L\,\Sigma\,(w) &= \Sigma\,(w\,z), \\ M\,\Sigma\,(w\,x^2) + N\,\Sigma\,(w\,x\,y) &= \Sigma\,(w\,x\,z), \\ M\,\Sigma\,(w\,x\,y) + N\,\Sigma\,(w\,y^2) &= \Sigma\,(w\,y\,z). \end{aligned}$$

The values of L, M, N being obtained, we may apply the equation (2) either to determine the value of z, when x and y are given, i. e., to deduce the *most probable value of the dip* for a given place,—or, conversely, to infer the relation of x and y when z is given, i. e. to determine the *equation of the line* passing through all the points of *given dip*. In this latter application let $z - L = K$, the equation of the line then is

$$M\,x + N\,y = K, \tag{4}$$

x and y being the co-ordinates, measured along the parallel of latitude and the meridian respectively. On this supposition, then, the isoclinal line is a *right line*, the angle which it makes with the meridian is

$$ang\left(tan = -\frac{N}{M}\right), \tag{5}$$

and the increase of the dip corresponding to each geographical mile of distance, in a direction perpendicular to the line, is

$$\sqrt{M^2 + N^2} \tag{6}$$

In this mode of computation it is assumed, not only that the portion of the earth over which the observations extend may be treated as a plane surface, but also that the differences of dip (or intensity) are *linear* functions of the differences of latitude and longitude,—in other words, that the isoclinal and isodynamic lines are *straight*. This supposition may be safely made, where the district of observation, itself inconsiderable in extent, is remote from the poles of dip or of intensity,

for in such cases the curvature of the lines not being rapid, the curve itself may, for a small portion of its extent, be confounded with its tangent. It suggests perhaps the best mode of determining with precision the empirical laws of the distribution of terrestrial magnetism; namely, by means of *small groups* of observations, each of which will give, by this method, not a *point* in the curve merely, but a portion of its *tangent*.

The extent of the district in which this method is available will, of course, vary with the curvature of the lines on the earth's surface, becoming more and more limited as we approach the poles. Where the flexure of the lines is rapid, and we seek, nevertheless, to combine the observations scattered over a moderately extensive tract of country, it becomes necessary to obtain some means of pushing the approximation further.

Such means readily present themselves. Whatever be the *laws* of distribution of magnetism on the surface of the earth, it is manifest that the dip (or intensity) at any station is a function of its co-ordinates of position, or that

$$z = \mathrm{F}(\alpha, \beta),$$

α and β denoting the co-ordinates of the station (in parts of radius) referred to some neighbouring station as an origin. Accordingly,

$$z = (z) + \left(\frac{d\,z}{d\,\alpha}\right)\alpha + \left(\frac{d\,z}{d\,\beta}\right)\beta + \tfrac{1}{2}\left(\frac{d^2\,z}{d\,\alpha^2}\right)\alpha^2 + \left(\frac{d^2\,z}{d\,\alpha\,d\,\beta}\right)\alpha\,\beta$$
$$+ \tfrac{1}{2}\left(\frac{d^2\,z}{d\,\beta^2}\right)\beta^2 + \&c.$$

the brackets denoting the particular values of the derived functions, when $\alpha = 0$, $\beta = 0$. The quantities α and β, in the preceding equation, being small, we may push the approximation as far as we please, by including a greater number of terms in the development.

Let the co-ordinates of linear distance be denoted, as before, by x and y,

$$\alpha = \frac{x}{r}, \quad \beta = \frac{y}{r};$$

r being the radius of the earth. Substituting these values in the preceding equation, and making

$$\mathrm{L} = (z),\ \mathrm{M} = \frac{1}{r}\left(\frac{d\,z}{d\,\alpha}\right),\ \mathrm{N} = \frac{1}{r}\left(\frac{d\,z}{d\,\beta}\right),\ \mathrm{P} = \frac{1}{2\,r^2}\left(\frac{d^2\,z}{d\,\alpha^2}\right),$$
$$\mathrm{Q} = \frac{1}{r^2}\left(\frac{d^2\,z}{d\,\alpha\,d\,\beta}\right),\ \mathrm{R} = \frac{1}{2\,r^2}\left(\frac{d^2\,z}{d\,\beta^2}\right),\ \&c.$$

we have

$$z = \mathrm{L} + \mathrm{M}\,x + \mathrm{N}\,y + \mathrm{P}\,x^2 + \mathrm{Q}\,x\,y + \mathrm{R}\,y^2 + \&c. \qquad (7)$$

If we retain only the terms of this equation in which x and y are of the first dimension, we have the equation (2) already obtained.

To advance another step in the approximation, we should include the terms in which x and y are of the *second* dimension, and we shall thus have six unknown coefficients L, M, N, P, Q, R, to be determined. For this purpose, the equations (in number the same as the stations of observation) are to be combined by the method of least squares, and the six resulting equations will give, by elimination, the quantities sought.

The coefficients L, M, N, &c. being known, the line of *given dip* is

$$R\,y^2 + Q\,x\,y + P\,x^2 + N\,y + M\,x = K, \tag{8}$$

in which K denotes, as before, the particular value of $z - (z)$. Here, then, the isoclinal line is of the *second order*; and its species is determined by the relation of the first three coefficients, P, Q, R. The equation of the curve being found, it is easy to construct it graphically by points.

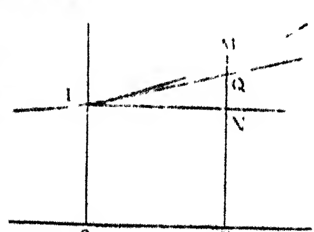
The preceding solution of the problem is probably sufficient for all purposes; but the determination of six unknown quantities by the method of least squares, when the equations of condition are numerous, is a formidable labour; and it is therefore important to consider whether we can safely stop short at any step of less generality. Now it is easily seen that in most cases to which we have to apply this method, the isoclinal line may be represented by the equation

$$P\,x^2 + N\,y + M\,x = K, \tag{9}$$

in which there are only four coefficients to be determined*. This equation (considered as belonging to a plane curve) is that of a *parabola*

The equation, being *linear* in *one* of the co-ordinates, is very easily constructed by points.

* This is evident from geometrical considerations Let L M be a portion of the curve, referred to the axes of co-ordinates O P, O L, and let L Q be its tangent at the point L, making with the axis of abscissæ an angle whose tangent is a The ordinate of the curve P M, is equal to P Q + Q M. But P Q, the ordinate of the tangent, is equal to $a\,x + b$, b denoting the ordinate at the origin, O L And the sagitta Q M, is proportional to Q L², the arc being small in proportion to the radius of curvature; i e. $QM = k \times QL^2 = k\,(1 + a^2)\,x^2 = c\,x^2$. Hence



$$y = b + a\,x + c\,x^2.$$

The object proposed in the preceding method has been attained by Major Sabine by a different process, which will be applied by him in the sequel. It is therefore unnecessary to make any application of that here laid down

In combining the equations of condition by the method of least squares, it is manifest that we cannot, in general, allow *equal weight* to all The result obtained at one station may be derived from a single observation only, while, at another, it may be the *mean* of several observations, made at different times, and with different instruments In a former discussion of the observations in Ireland, weights were assigned to the results at each station, but on arbitrary and uncertain principles I now proceed to remedy this defect, and I do so the more willingly, both on account of the great importance of this branch of the theory of probabilities in Physical science, and because the results to be referred to are connected with researches not as well known as they deserve

Let x_1, x_2, x_3, &c, x_n, be n values of the quantity x, obtained by separate and independent observations, and let a denote their arithmetical mean, so that

$$a = \frac{1}{n}\left(x_1 + x_2 + x_3 + \&c. + x_n\right),$$

then the *probable error* of this mean, i e the limit on either side of which there are *equal chances* of the actual error lying, is given by the formula

$$E^2 = \frac{2\rho^2 \Sigma (x - a)^2}{n(n-1)}, \tag{10}$$

in which $\Sigma (x - a)^2$ denotes the sum of the squares of the differences of the several partial results and the mean, or the value of

$$(x_1 - a)^2 + (x_2 - a)^2 + \&c + (x_n - a)^2,$$

and in which, also, ρ is the number which satisfies the equation

$$\int_0^\rho e^{-t^2} dt = \tfrac{1}{4}\sqrt{\pi}.$$

Numerically, $\rho = 0\ 4769$, and substituting in (10)

$$E^2 = \frac{\cdot 4549\, \Sigma (x - a)^2}{n(n-1)} \tag{11}$$

The probable error of a *single* result, as deduced from comparison with the rest, is in like manner given by the formula

$$\epsilon^2 = \frac{\cdot 4549 \, \Sigma \, (x - a)^2}{n - 1} \qquad (12)$$

so that $\epsilon^2 = n \, E^2$. The *weights*, in both cases, are measured by the inverse of the squares of the probable errors; that is

$$W \, E^2 = 1, \; w \, \epsilon^2 = 1, \qquad (13)$$

w and W denoting the weights of the single result, and of the mean, respectively*.

When the quantity sought is a *linear* function of two or more unknown quantities, which latter are obtained immediately by observation, its probable error is connected with those of the quantities on which it depends by a very simple relation.

Let x and y be the quantities sought by *immediate* observation, and let the quantity actually sought, z, be a linear function of these, expressed by the equation

$$z = p \, x + q \, y.$$

Let a denote the arithmetical mean of m observations of the unknown quantity x, b the mean of n observations of y, and let E_x and E_y be their *probable errors*, or the limits on either side of which there are *equal chances* of the actual errors, $x - a$, $y - b$, being found. Then the probable error of z, E_z, is expressed by the formula†

$$E_z^2 = p^2 \, E_x^2 + q_2 \, E_y^2. \qquad (14)$$

The case of a linear function includes every case in which the quantities sought are already approximately known. We have only to substitute for these quantities their approximate values *plus* the unknown corrections, and to neglect the squares and higher powers of the latter.

To apply these principles to an important case,—let it be required to determine the probable error (or the weight) of the mean dip at a given station, as deduced from n_o observations, with n_i instruments.

The true dip being equal to the observed dip *plus* the instrumental correction, it is manifest that, in this case,

$$E^2 = E^2_{\,o} + E^2_{\,i};$$

* For the demonstration of these theorems, the reader is referred to a paper by Prof Encke, in the *Astronomisches Jahrbuch* for the year 1834. See also a paper by M. Poisson on the same subject in the *Connoissance des Temps*, 1827.

† See a paper by M. Poisson in the *Bulletin Universel des Sciences*, tome xiii. p 266 See also the Memoir by Prof. Encke, already referred to.

E_o denoting the error of observation, and E that due to the imperfection of instruments. But

$$E_o^2 = \frac{\epsilon_o^2}{n_o}, \quad E_i = \frac{\epsilon_i^2}{n_i},$$

ϵ_o denoting the probable error of a single observation, and ϵ_i that of a single instrument. Hence

$$E^2 = \frac{\epsilon_o^2}{n_o} + \frac{\epsilon_i^2}{n_i}. \tag{15}$$

We have here taken no *separate* account of the error arising from the *variations* of the dip, that error being inseparably combined with the error of observation; the symbol ϵ_o, therefore, in the preceding, denotes the probable error resulting from the two conjoint sources.

In order to estimate the value of ϵ_o, I have taken the following series of observations, made with the needles, L. 1, L. 4, in Dublin, the longest series of observations made with the same instrument at a single station in Ireland. The 1st column of the table contains the *dates* of observation; the 2nd the *observed dips* (uncorrected); the 3rd the *reduced* dips, referred to the 1st of January, 1836. In the 4th column are the differences between the partial results and the mean, and in the 5th, the squares of these differences.

Table XXVII.

Needle L. 1.

Date	Observed Dip.	Reduced Dip. $=\theta$	$\theta - a$	$(\theta - a)^2$
Oct 21, 1833	70° 58'·4	70° 51'·2	− 0·4	0·16
Aug 7, 1834	70 51·6	70 48·2	− 3·4	11·56
— 8,	70 57·6	70 54·2	+ 2·6	6·76
— 9,	70 54·3	70 50·9	− 0·7	·49
— 19,	70 49·5	70 46·1	− 5·5	30·25
Sept 22,	70 56·0	70 53·0	+ 1·4	1·96
— 23,	70 53·8	70 50·8	− 0·8	·64
Sept 4, 1835	70 46·7	70 45·9	− 5·7	32·49
— 5,	70 55·6	70 54·8	+ 3·2	10·24
— 7,	70 54·2	70 53·4	+ 1·8	3·24
— 9,	70 54·4	70 53·6	+ 2·0	4·00
— 14,	70 56·7	70 55·9	+ 4·3	18·49
— 15,	70 53·3	70 52·5	+ 0·9	·81

TABLE XXVIII. Needle L. 4.

Date	Observed Dip	Reduced Dip	$x-a$	$(x-a)^2$
Sept 22, 1834	71° 2′·2	70° 59′·2	+ 9·1	82·81
— 23,	70 53·8	70 50·8	+ 0·7	0·49
— 29,	70 41·8	70 41·8	− 8·3	68·89
Oct 25,	70 51·1	70 51·3	+ 1·2	1·44
Aug 19, 1835	70 51·6	70 50·8	+ 0·7	0·49
Sept. 4,	70 43·6	70 42·8	− 7·3	53·29
— 5,	70 52·8	70 52·0	+ 1·9	3·61
— 7,	70 52·2	70 51·4	+ 1·3	1·69
— 9,	70 46·2	70 45·4	− 4·7	22·09
— 14,	70 53·4	70 52·6	+ 2·5	6·25
— 15,	70 55·0	70 54·2	+ 4·1	16·81
Nov 5,	70 49·6	70 49·2	− 0·9	0·81
— 5,	70 45·8	70 45·4	− 4·7	22·09
— 6,	70 53·9	70 53·5	+ 3·4	11·56
Apr 11, 1836	70 48·1	70 48·9	− 1·2	1·44
— 15,	70 47·1	70 47·9	− 2·2	4·84
May 7,	70 50·9	70 51·7	+ 1·6	2·56
— 9,	70 56·4	70 57·2	+ 7·1	50·41
Aug. 5,	70 43·1	70 44·5	− 5·6	31·36
— 6,	70 51·3	70 52·7	+ 2·6	6·76

From the former of these tables we find

$$n = 13, \ a = 70^\circ \ 51'{\cdot}6, \ \Sigma\,(x-a)^2 = 121{\cdot}09\,;$$

and from the latter

$$n = 20, \ a = 70^\circ \ 50'{\cdot}1, \ \Sigma\,(x-a)^2 = 389{\cdot}69.$$

Substituting these numbers in (12), the probable error of observation in the former series is found to be $2'{\cdot}1$; and in the latter $3'{\cdot}0$.

It is remarkable that the squares of these errors (the inverse of which are the measures of the weights) are, almost exactly, in the ratio of 1 to 2; that is, in the inverse ratio of the number of readings with each needle. This is a curious confirmation of the accuracy of the conclusion.

From the preceding it follows, that in combining the results of the two needles, L. 1 and L. 4, (when used together) *double* weight must be allowed to the former. It appears from (14) that the probable error of the mean, thus deduced, is $1'{\cdot}8$. We may therefore consider *two minutes* as the probable error of observation in the present series, whether the result be that of a single needle with the usual number of readings, or the mean of the two needles L. 1 and L. 4.

The *probable instrumental error*, e_i, varies, of course, within very wide limits, depending on the perfection of workmanship. In a former part of this memoir, Major Sabine has pointed out the very great improvement which our English dipping needles

have undergone in this respect, subsequently to the year 1835* The mean error, for any set of needles, may be obtained from (15), when we have made a series of observations with these needles at any one station. Let ϵ denote the probable error of the result given by any set of observations with a single needle, as inferred from comparison with the others; Then $\epsilon^2 = n_i E^2$, and substituting in (15), we have

$$\epsilon^2_i = \epsilon^2 - \frac{n_i}{n_o} \epsilon^2_o,$$

in which the value of ϵ^2 is deduced from the observations by means of (12).

To deduce, according to these principles, the value of ϵ_i for the needles employed in the Irish survey, we must compare the results obtained at Limerick,—that being the only station where all the needles were employed. These results are contained in the following table. The first column contains the names of the needles employed, the second, the dips obtained, reduced to the 1st of January, 1837, of which the mean value is 71° 0′.5, in the 3rd column are the differences of the partial results and the mean; and in the 4th, the squares of these differences.

TABLE XXIX.

Needle	Dip $= x$	$x - a$	$(x - a)^2$
	° ′		
S 2	71 2·6	+ 2·1	4·41
M	71 1·4	+ 0·9	0·81
S 1†	70 57·6	− 2·9	8·41
S 1†	70 59·1	− 1·4	1·96
L. 1	71 4·7	+ 4·2	17·64
L 4	70 57·7	− 2·8	7·84

From the last column of the preceding table we find $\Sigma (x - a)^2 = 41 \cdot 07$; and substituting in (12), $\epsilon^2 = 3 \cdot 70$.

Again, $n_i = 6$, $n_o = 26$, and, assuming $\epsilon_o = 2$, $\frac{n_i}{n_o} \epsilon^2_o = 0 \cdot 92$.

* The probable instrumental error of the needles employed at Westbourne Green in 1835, as deduced from the observations recorded in the Irish Report (Fifth Report, p 142), amounts to 8′.3. The mean probable error of the needles employed at the same place in 1837 and 1838, as deduced from the observations contained in Table III. of the present memoir, is about *one minute* only

† The needle S 1 had undergone a change in the disposition of its axle in the interval between the two observations recorded in this table. These observations must therefore (as far at least as the axle is concerned) be regarded as the results of *different* instruments.

We have, therefore, from the preceding formula, $\epsilon^2_{,} = 2{\cdot}78$, and

$$\epsilon_{,} = 1'{\cdot}7.$$

It appears, then, that the instrumental error is somewhat less than the error of observation. The difference, however, is probably less than the error of our result, and we shall assume, in round numbers, *two minutes* as the amount of each error in the Irish series.

Taking, then, $\epsilon_{,} = \epsilon_{o} = 2$, we have (15) (13)

$$E^2 = \frac{1}{W} = 4\left(\frac{1}{n_o} + \frac{1}{n_{,}}\right). \qquad (16)$$

From this formula we learn how useless it is to multiply observations with the *same* instrument, in order to obtain the dip at a given station. When $n_{,} = 1$, we have

$$\frac{1}{W} = 4\left(\frac{1}{n} + 1\right), \quad \frac{1}{w} = 4 \times 2;$$

w denoting the weight of a single observation; so that

$$\frac{W}{w} = \frac{2\,n_o}{n_o + 1},$$

and, however the observations be multiplied, the weight of the result can never amount to *double* the weight of a single observation.

In what precedes, we have considered only the *actual* dip at a given station. But in deducing the position of the isoclinal lines from observations of dip made at several stations, it is necessary to consider likewise the probable difference between this dip and that due to the geographical position of the station: or, in other words, the probable mean *local error*.

Let ϵ_l denote this error; then it is manifest, from what has been already said, that the actual resulting error will be expressed by the formula

$$\epsilon^2 = \frac{\epsilon^2_o}{n_o} + \frac{\epsilon^2_{,}}{n_{,}} + \epsilon^2_l. \qquad (17)$$

The mean local error will, of course, be very different in different countries, the differences depending chiefly on the relative proportion of the igneous and sedimentary rocks. In Scotland, as appears from Major Sabine's excellent report (Sixth Report, p. 102), the local error is considerable; in England it is probably small. We may estimate its amount in any district, by *computing* the dip due to the geographical position of each station, by the formula (2), and taking the sum of the squares

of the differences between the computed and observed results. This, substituted in (12), will give the *total* mean probable error, or the value of ϵ in the equation (17) (n_o and n_i *now* denoting the *mean* number of observations, and of instruments, at each station), and, ϵ_o and ϵ_i being already known, we deduce the value of ϵ_t.

In addition to the observations of dip already printed in the Irish Magnetic Report, the following pages contain, 1st, a series of observations made by Robert W. Fox, Esq, at nine stations, chiefly in the West of Ireland, 2nd, observations made by Major Sabine, chiefly in Limerick, 3rd, my own observations in Dublin, and 4th, a series of observations made by Captain James Ross, at twelve stations, distributed uniformly over the whole island

Mr Fox's observations are contained in Table XXX. They were made in the autumn of the year 1835, at a time when the other parts of the Irish survey were in progress, but, Mr Fox not being at that time associated in our labours, his results were separately published*. They are now, with his permission, republished in the present memoir The instrument employed in these observations has been already described†.

Table XXX

Mr Fox's Observations in 1835.

Station	Date	Hour	Dip	Place of Observation
Dublin	Aug 17	11 A M	70° 59′	Garden of Trinity College
Galway	— 19	9½ A M	71 26	Hotel Garden
Gallhorick	— 19	3½ P M	71 41	Island in Lough Corrib
Clifden	— 22	2 P M	71 52	Hotel Garden
Westport	— 24	11¾ A M	72 3	Garden of Hotel (Sligo Arms)
Puntoon	— 24	6 P M	72 8	West side of Lough Conn
Ballina	— 25	10 A M	72 7	Hotel Garden
Giant's Causeway	— 27	4½ P M	73 15	East side
Cushendall	— 28	9½ A M	72 0	Hotel Garden

Major Sabine's additional observations, contained in Table XXXI, were made at Limerick, Dublin, and Bangor, in the year 1836‡. These observations have been already printed

* Proceedings of the Cornwall Polytechnic Society

† Page 3

‡ With the exception of one set of observations made with Mayer's needle in the year 1833 These observations, though referred to in the Irish Report, were overlooked in the compilation of the tables

in the Scotch Magnetic Report, and are reprinted here, so as to have all the data connected with Ireland present in one view The needles employed, (Mayer's needle and needles S. 1, S. 2,) have been already described.

TABLE XXXI

Major Sabine's Observations.

Station	Date.		Hour	Needle	Dip.
Limerick .	Nov. 1,	1833	1 P.M	Mayer's.	71 11·0
—	— 2 & 4,	1833	1 P.M	—	71 11·9
— .		Mean.		—	71 11·5
Limerick .	May	1836.		Mayer's.	
— ...	June			—	
— ..		Mean...			71 0·0
—	May	1836		S 1	71 0·6
Limerick.	Feb. 20,	1836	1 P.M.	S 2	71 13·4
Limerick	May 5		11 A.M.	—	71 13·0
—	— 5		1 P.M.	—	71 11·0
— .		Mean...		—	71 12·0
Dublin ...	July 22,	1836.	Noon	—	71 14·1
— ...	— 22		1 P.M	—	71 11·6
— .	— 23		Noon	—	71 13·7
—		Mean.	7½	—	71 13·1
Bangor ..	Sept. 21,	1836	10 A.M.	—	71 48·7
Dublin	Oct 4		1 P.M	—	71 12·7

My own additional observations were confined to Dublin, and were made in the years 1836 and 1838. The observations of the former year, contained in Table XXXIII, were made with the statical needles, L. 3 and L. 4, already described. Those of the latter, (Table XXXII), with the dip circle, and needle G. 2 made by Gambey*, and with another circle of the same size, and two needles, made by the same distinguished artist for the Dublin Observatory. All these latter observations were made according to the method of *arbitrary azimuths*. In conjunction with the observations of Captain Ross in Dublin, they are taken as the basis on which the determination of the corrections of my other needles, L. 1, L. 3 and L. 4, is made to rest.

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Table XXXII.

Mr Lloyd's Observations in Dublin in 1838.

Gambey's Needles.—Method of Arbitrary Azimuths.

Needle Date	Azim *	Angle.	Azim	Angle	Mean Angle.	Dip
G 2 Aug. 3, 4, 6, 7	0°	70° 49′ 8	180°	70° 56′ 0	70° 52′·9	° ′ 70 52·8
	90	89 13 1	270	89 19 1	89 16 1	
	10	71 1 1	190	71 11 6	71 7 8	70 52 6
	100	86 42 2	280	86 37 2	86 39 7	
	20	71 54 0	200	71 59 1	71 56 5	70 56 0
	110	83 33 0	290	83 21 9	83 27 5	
	30	73 11 4	210	73 19·4	73 15·4	70 50 0
	120	80 27·4	300	80 13·9	80 20·6	
	40	75 0 9	220	75 4·0	75 2 5	70 55·1
	130	77 40 2	310	77 32·4	77 36·3	
	50	77 20 4	230	77 21 0	77 22 2	70 5[illegible] 3
	140	75 17 9	320	75 11 1	75 14 5	
	60	80 1 0	240	80 8 6	80 4 8	70 56 0
	150	73 28 0	330	73 20 0	73 24 0	
	70	83 4 4	250	83 8·5	83 6 5	70 55 1
	160	72 6 4	340	71 59·1	72 2 8	
	80	86 16 5	260	86 23·0	86 19·8	70 52 6
	170	71 14 8	350	71 7 1	71 11·0	
D 1 Sept 25, 26	0	70 59 1	180	71 1 9	71 0 5	71 0 5
	90	89 53 5	270	89 52 3	89 52 9	
	30	73 11 1	210	73 19 5	73 15 3	70 52 7
	120	80 16 2	300	80 11 0	80 13 6	
	60	80 9 6	240	80 16 9	80 13 3	70 55·6
	150	73 20 7	330	73 17·1	73 18 9	
D 2 Sept. 27, 28	0	70 55 9	180	71 1·7	70 58·8	70 58 8
	90	89 51 2	270	89 53 0	89 52 1	
	30	73 16 1	210	73 29 1	73 22 6	70 59·3
	120	80 22 0	300	80 6 8	80 14·4	
	60	80 16 0	240	80 24 9	80 20 5	71 2 5
	150	73 26·7	330	73 19 5	73 23·1	
D 2 Oct. 1, 2	15 †	71 26 0	195	71 32·6	71 29·3	70 58·3
	105	85 19 4	285	85 13 4	85 16·4	
	45	75 53·9	225	75 59·4	75 56·6	70 53 5
	135	76 33·6	315	76 30·4	76 32·0	
	75	84 28·3	255	84 31 1	84 29 7	70 59 9
	165	71 46 7	345	71 38 1	71 42 4	

* The Azimuth 0° is the magnetic meridian, the face of the instrument being to the east The azimuths increase in the order N., E., S., W.

† The azimuths in this last observation are set down in a round number of degrees. They were (exactly) 14° 15′, 44° 15′, 74° 15′, &c.

Table XXXIII.

Mr. Lloyd's Observations in Dublin in 1836.

Date	Needle L. 3.		Needle L. 4.	
	Hour	Dip	Hour	Dip
	h m	° ′	h m	° ′
April, 11	12 18	70 53·4	12 43	70 48·1
— 15	12 30	71 0·0	12 8	70 47·1
Mean ..	12 24	70 56·7	12 25	70 47·6
May 7	1 32	70 56·5	1 10	70 50·9
— 9.	1 25	71 0·9	12 50	70 56·4
Mean ..	1 28	70 58·7	1 0	70 53·6
Aug 5	3 50	70 54·7	3 28	70 43·1
— 6	2 35	70 58·4	2 10	70 51·3
Mean..	3 12	70 56·5	2 49	70 47·2

The observations of Captain Ross were made in October and November, 1838, with the needles designated as R. 4, R. 5, R. 6, R. 7, L. 3, L. 4, in the preceding pages. The stations of observation being sufficiently numerous, as well as uniformly distributed, it has been thought advisable to combine them in a separate determination. The observations are contained in Tables XXXIX. and XL.

We have now to consider the actual errors of the instruments employed in the preceding observations.

The errors of dipping needles may be ascribed to one or other of the three following causes: namely, 1, the *friction* of the axle on its supports; 2, the *imperfect curvature* of the axle itself; 3, *magnetism* in the limb.

It is owing to the first-mentioned cause that a dipping needle assumes, in general, a new position of equilibrium after it has been disturbed, the limit of error being the angle at which the directive force, increasing as the sine of the deviation, becomes equal to the friction. This limit varies, for a given state of polish of the axle and of its supports, with the *radius* of the cylindrical axle, the *weight* of the needle, and its *directive force* *. In all the earlier dipping needles constructed in this country, this limit of error is considerable, owing to the unnecessary size of the axle.

The errors arising from the two latter causes are, however, of a very different nature. The *positive* and *negative* errors due to friction are *equally probable*, and the effect of the dis-

* *Trans Royal Irish Academy* Vol. xvii p. 166

turbing cause is merely to widen the limits of probable error. The imperfect curvature of the axle, and the magnetism of the limb, act however very differently. Either of these sources of error must, at a given place, affect all the results in the *same manner*, and, consequently, no repetition of observation, with an instrument so circumstanced, can afford even an approximation to the true dip. At different places the error will be different, and will vary according to no assignable law.

The course to be pursued by the observer with reference to these errors is manifest. Their existence or non-existence should be ascertained at the outset by one or other of the means pointed out by Major Sabine in the commencement of this memoir, and if found to surpass certain limits, the instrument should be rejected. The case is different, however, when the instrument has been actually employed for some time previously to the detection of the error. Here we must seek, if possible, to determine the probable amount of the error, and apply it, with an opposite sign, as a correction to the results. Where the district of observation is limited, this is practicable. It will be easily understood, that the imperfect curvature of the axle, or the disturbing action of the limb, must, within a moderate range of dip, affect all the results in the *same manner*, so that they will all require a correction having the *same sign*; and that when the range of dip is *very small*, the *amount* of the disturbance will be nearly the same throughout, and consequently the correction required will be *nearly constant*. In such a case then we have only to determine the amount of the error at some one station, by a comparison of the results with those of proved needles obtained at the same place, and, if possible, at the same time.

Again, in needles whose poles are unchanged, gravity acts with a certain moment *with* or *against* the directive force; the coincidence of the centre of gravity with the axle being rarely attained. The observed inclination, therefore, deviates from the true dip, and the amount of this deviation varies in different places, according to a known law*. To obtain its actual value, however, at *any* station, it must be known at some *one*; and this knowledge is to be obtained, as before, by a comparison of the results with those of other needles at that sta-

* Fifth Report, p. 144. With needles whose poles are inverted in each observation, the true dip may be inferred from the observed angles of inclination, however considerably they may deviate from it. In such needles, therefore, the non coincidence of the centre of gravity with the axle cannot properly be ranked among the sources of error.

tion. When the district of observation is limited, the *variation* of this quantity may be disregarded.

The importance of an exact determination of these needle-corrections is very great in the present instance. When, indeed, the *same* needle is employed throughout an entire series of observations (as was done by Major Sabine in Scotland), it is manifest that any error in the amount of its correction will have the effect only of displacing the isoclinal lines in *absolute position*, leaving their *direction* and *interval* unaltered. For the direction and interval of the lines depend solely on the *differences* of dip, and these are manifestly independent of the correction, which alters all the dips by the same amount. The case is different, however, when (as in the present instance) *different* needles requiring correction are employed in the same series Here the differences of dip cannot be known, unless we know the differences of the corrections of the needles employed; and it is manifest that any error in the amount of that difference will displace one entire group of results relatively to the rest, and thus (when the mean geographical position of these groups is different) induce a grave error in the direction of the lines.

Before we proceed to determine the amount of these errors in the needles employed in the Irish survey, it may be desirable to make a few remarks on *their* particular causes.

Of the two sources of error above mentioned, the *imperfection of axle* appears to be the most common; and it is to it we are to ascribe (as Major Sabine has already remarked*) the chief part of the discordances in the results obtained at Westbourne Green in 1835 The same series, however, affords likewise a remarkable instance of the other error Having purposely destroyed the balance in two of my dipping needles, so that they rested nearly in the horizontal position in Dublin, I proceeded to use them exclusively for observations of intensity. The results thus obtained were, however, so anomalous, that I was compelled to reject them altogether. After some tedious and vain attempts to discover the source of the anomaly, I was at length satisfied, by a careful inspection of the results, that the needles were under the influence of some other force besides the earth's magnetism and gravity, and I concluded that this disturbing force could be no other than magnetism in the dip circle itself. Trial soon verified this conjecture, and I had the mortification to find that the apparatus which I had been so long using was *throughout* magnetic, and that the magnetism†

* Page 46

† Magnetism *induced* in ferruginous matter, not permanent

was greatest in the graduated limb, the very part in which, from its proximity to the needle, it must operate most powerfully

I had next to consider the painful question,—How far the numerous results obtained with this instrument were vitiated by this newly-discovered source of error? Whether they were entitled to any confidence, and if so, what were the probable limits of error? It is manifest that if the ferruginous matter were *uniformly* distributed throughout the limb, it could produce no disturbance in the position of a needle which (like the dipping needle) divides the limb symmetrically It is only by an irregularity in its distribution that the magnetic matter of the limb can operate as a disturbing cause, and then it is manifestly only by the *difference of the attractions*, on the two sides of each pole, that the needle is actually disturbed. Hence, though the magnetism of the limb may produce very decided effects upon a test needle, in a position at right angles to its plane, the effect upon a dipping needle may be comparatively trifling

In order to estimate the amount of these effects, I separated the divided circle from the apparatus, and placed it on a horizontal support of wood Three strong pins in contact with the inner edge of the limb, and dividing it equally, were then driven into the support, so as to prevent the limb from having any motion, except one of rotation in its own plane. A magnetic bar, whose length was nearly equal to the diameter of the circle, was then supported delicately within it, and the deviation of the bar from its undisturbed position was observed in the different positions of the limb with respect to it. It was thus found that most parts of the limb exerted a sensible disturbing effect upon the needle, and that this effect was not only considerable in the neighbourhood of the two zero points of the limb (the part where the anomalies had been first observed), but that it also varied there *very rapidly* A detailed examination of the effects in this position showed that there was a disturbing centre of ferruginous matter in the neighbourhood of each of these points, and that it was to the action of these centres that the anomalies in the observations above alluded to were owing

In the neighbourhood of the divisions of 70° the disturbance of the needle was likewise considerable, and its direction was such as to diminish the apparent dip Here, then, we have the cause of the large *negative error* of the results obtained with this instrument But this deflection did not vary rapidly on either side of these positions, so that for small changes of dip

the error may be regarded as nearly constant*. Defective, therefore, as the apparatus is in this respect, there is reason to conclude that the *differences of dip* obtained with it in Ireland may be relied on within the usual limits of probable error, and that to obtain the true dip from the observed results, we have only to apply a *positive* correction, which may be regarded as *constant* throughout the series.

The instrument referred to in the preceding pages having been much employed in Dublin, and with very consistent results, we shall take, as the basis of its correction, the dip in Dublin as deduced from the observations with Gambey's needles, Table XXXII. In these observations, made according to the method of arbitrary azimuths, the bearing points of the axle, and the position of the needle with respect to the limb, are different in each azimuth, so that the results may be regarded as, virtually, the results of *different* instruments. Their accordance is sufficient to show that the errors of axle and of limb are inconsiderable. For the convenience of reference, the observations are put together in the following Table; the dips being reduced to the 1st of January, 1838.

Table XXXIV.

Needle.	Azimuth	Dip.	Needle		Azimuth	Dip.
Gambey's Needle, G. 2, belonging to Capt. FitzRoy.	0 & 90	70 54·2	Gambey's Needles, belonging to the Dublin Observatory.	D (1)	0 & 90	71 2·3
	10 & 100	70 54·0			30 & 120	70 54 5
	20 & 110	70 57 4			60 & 150	70 57·4
	30 & 120	70 57 4		D (2)	0 & 90	71 0·6
	40 & 130	70 56·5			15 & 105	71 0 1
	50 & 140	70 56·7			30 & 120	71 1·1
	60 & 150	70 57·4			45 & 135	70 55 3
	70 & 160	70 56·8			60 & 150	71 4 3
	80 & 170	70 54 0			75 & 165	71 1·7

The mean of these results is 70° 57′·9. If we combine with this the mean result obtained by Captain Ross at the same place, as deduced from six observations with four needles, and reduced to the same epoch, (namely, 71° 1′·7,) we have, for the mean dip in Dublin, on the 1st of January, 1838,

70° 58′·8.

* A comparison of the results with those of other instruments seems to point to the conclusion that this error diminishes with the dip, and is somewhat less in England than in Ireland.

To compare with this, we have the following observations with the needles L. 1, L. 3, L. 4, in Dublin.

TABLE XXXV.

Needle	No	Date	Observed Dip	Reduced Dip	Mean Dip
L 1	1	Oct. 21, 1833	70° 56′·4	70° 46′·4	
—	6	Aug 25, 1834	70 53·8	70 45·8	70° 46′·8
—	6	Sept. 9, 1835	70 53·5	70 47·9	
L 3	4	Apr 25, 1836	70 57·7	70 53·7	
—	2	Aug 5, 1836	70 56·5	70 53·1	70 53·5
L 4	4	Oct 2, 1834	70 53·7	70 45·9	
—	7	Sept 6, 1835	70 50·7	70 45·1	
—	3	Nov 5, 1835	70 49·8	70 44·6	70 45·4
—	4	Apr 25, 1836	70 50·6	70 46·6	
—	2	Aug. 5, 1836	70 47·2	70 43·8	

Hence we obtain the following corrections:

Needle L. 1, correction $= + 12'{\cdot}0$
,, L. 3 ,, $= + \ 5'{\cdot}3$
,, L. 4 ,, $= + 13'{\cdot}4$

In L. 3 and L. 4, needles whose poles are unchanged, the errors here deduced are, of course, those which result from the moment of the needles' weight, combined with that arising from the disturbing action of the limb.

The *weights* due to these corrections are at once deduced from the principles of the preceding pages. When the results of one needle, at a given station, are compared with those of others, and that we seek their *difference*, it is manifest that $p = 1$, $q = 1$, (14), and that, consequently,

$$E^2 = E_1^2 + E_2^2;$$

E_1 denoting the probable error of the *mean* result of the given needle, and E_2 that of those with which it is compared. When we look no further than the *actual* difference of the results at the one station, it is manifest that

$$E_1^2 = \frac{e_1^2}{n_1}, \quad E_2^2 = \frac{e_2^2}{n_2};$$

e_1 and e_2 denoting the probable errors of a single observation, in the needles compared, and n_1 and n_2 the number of obser-

vations. Hence, if $\epsilon_1 = \epsilon_2$, that is, if the reading power be the same in the two cases, and the same pains be bestowed on the observations,

$$\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2}, \tag{18}$$

n denoting the value of the ratio $\frac{\epsilon''}{E_2^2}$, or the *equivalent* number of observations of the difference sought, supposing it to be the immediate subject of observation.

But when we desire to compare the result of the uncorrected needle with the *actual dip*, we must also take into account the probable *instrumental error* of the results with which it has been compared; and we have (15)

$$E_2^2 = \frac{\epsilon_2^2}{n_2} + \frac{\epsilon_i^2}{n_i}.$$

And in place of equation (18), we have the following:

$$\frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{\epsilon_i^2\, n_1}{\epsilon_{\prime\prime}^2\, n_i}. \tag{19}$$

To apply this, we shall assume, as before, the instrumental error to be equal to the error of observation, the latter including the error of epoch; and we obtain

Needle L. 1, $n_1 = 13$, $n = 6\cdot1$,
— L. 3, — — 6, — — $3\cdot9$,
— L. 4, — — 20, — — $7\cdot3$.

We shall adopt the nearest whole numbers, 6, 4, 7.

The correction of needle S. 2 has been determined with great care by Major Sabine*, by a comparison, at various stations, of its results with those of the needles M and G. 2, needles which may be regarded as almost free from all instrumental error. The amount of this correction is $-9'\cdot6$; and its weight 16. This amount is almost identical with that previously employed in the calculation of the Irish observations.

The other needle employed by Major Sabine in Ireland, S 1, is constructed on a plan suggested by Mr. Dollond. The middle of the needle has the form of a cube, and is perforated so as to receive the axle in different directions, the intention being, that the position of the axle should be varied in the

* Table XIX

course of every observation. From some defect of workmanship, however, the balance of the needle was much deranged in some positions of the axle, and it was accordingly employed by Major Sabine as an ordinary dipping needle, the axle being permanently fixed in one position in which the needle was tolerably balanced. This was the case during the observations made with it in August, September, and October, 1834 (Fifth Report, p. 139), the axle being undisturbed during the whole of the series. In 1835, when Captain Ross used this needle at Westbourne Green, the axle had been repolished, and was, moreover, fixed by the artist in a different position from that which it had occupied during the observations of the preceding year. So far, therefore, as axle error is concerned, the needle must, then and thenceforward, be regarded as a different needle.

In order to deduce the amount of the axle error, previously to the alteration just alluded to, we may compare the result obtained with this needle at Limerick, in August 1834, with the mean dip of the place as given by other needles. The difference (4'.2) is probably not greater than the probable error of observation, which, owing to the imperfect polish of the axle, was in this needle considerable. Under these circumstances, we are not justified in assigning to it any correction.

The needles employed by Mr. Fox appear to give results extremely consistent with one another, and with those of other needles. In their case, therefore, no correction is required.

We are now prepared to exhibit in one view the mean* values of the dip, as deduced from these various needles. The following table contains the results of observations arranged chronologically, and *corrected* as has been above explained.

* Where the needles L. 1 and L. 1 have been employed together, double weight has been allowed to the results of the former in taking the mean, in accordance with the conclusion of page 98.

Table XXXVI.

Corrected Dip.

Station	Date		Needle	No	Dip	Mean Dip
Dublin	Oct. 21,	1833	L. 1	1	71 8·4	71 8·4
Limerick	Nov.	1833	M	4	71 11·7	71 11·7
Limerick	July,	1834	L. 1	5	71 11·5	71 11·5
Dublin	Aug Sept.		L. 1	6	71 5·8	71 6·1
—	Sept. Oct		L. 4	4	71 7·1	
Limerick	Aug 1, 16		S. 1	2	71 3·5	71 3·5
Glengarriff	Sept 27, 28		S. 1	2	71 1·5	71 1·5
Killarney	Oct. 1		S. 1	1	71 4·5	71 4·5
Tulla	— 12		S. 1	1	71 15·8	71 15·8
Carlingford	— 13		L. 1	1	71 28·3	71 30·2
—	— 13		L. 4	1	71 34·0	
Armagh	— 14, 15		L. 1	2	71 43·5	71 42·2
—	— 14, 15		L. 4	2	71 39·7	
Colerain	— 20		L. 1	1	71 27·6	71 26·9
—	— 20		L. 4	1	71 25·6	
Carn	— 21		L. 1	1	71 59·8	72 0·9
—	— 21		L. 4	1	72 3·0	
Strabane	— 23		L. 1	1	72 3·6	72 0·0
—	— 23		L. 4	1	71 52·8	
Enniskillen	Oct. 24	1834	L. 1	1	72 0·0	72 0·0
Fermoy	Dec. 2		L. 1	1	70 48·3	70 48·3
Limerick	July,	1835	S. 2	4	71 7·3	71 7·3
Dublin	Aug. 17		F		70 59·0	70 59·0
Galway	— 19		F		71 26·0	71 26·0
Gallhorick	— 19		F		71 41·0	71 41·0
Clifden	— 22		F		71 52·0	71 52·0
Westport	— 24		F		72 3·0	72 3·0
Puntoon			F		72 8·0	72 8·0
Ballina	— 25		F		72 7·0	72 7·0
Giants Causeway	— 27		F		73 15·0	73 15·0
Cushendall	— 28		F		72 0·0	72 0·0
Markree	— 21		L. 1	2	72 5·6	72 6·3
—	— 21		L. 4	1	72 9·0	
Ballina	— 22		L. 1	1	72 13·9	72 11·0
—	— 22		L. 4	1	72 5·2	
Belmullet	— 24		L. 1	1	72 14·7	72 13·4
—	— 24		L. 4	1	72 10·9	
Achill	— 25		L. 1	1	72 6·4	72 6·5
—	— 25		L. 4	1	72 6·6	
Galway	— 28		L. 1	1	71 33·9	71 32·9
—	— 28		L. 4	1	71 30·8	

Station	Date	Needle	No	Dip	Mean Dip.
Ennis .	Aug 28	L. 1	1	71 13·5	71 13 2
——	— 28	L. 4	1	71 12 5	
Limerick	— 29	L. 1	1	71 3 9	71 2 9
——	— 29	L. 4	1	71 0 9	
Cork .	— 31	L. 1	1	70 41 3	70 43·1
——	— 31	L. 4	1	70 46 6	
Waterford	Sept 1	L. 1	1	70 49 6	70 50 5
——	— 1	L. 4	1	70 52 2	
Broadway .	— 2	L. 1	1	70 31 4	70 35 9
——	— 2	L. 4	1	70 45·0	
Gorey	— 3	L. 1	1	70 55 4	70 55 8
——	— 3	L. 4	1	70 56 5	
Rathdrum	— 3	L. 1	1	70 53·1	70 53·5
——	— 3	L. 4	1	70 54 2	
Dublin . .	Sept 4—15	L. 1	6	71 5·5	71 5·0
——	Aug. Sept.	L. 4	7	71 4·1	
——	Nov. 5, 6	L. 4	8	71 3·2	71 3·2
Ballybunan	— 8	S. 2	1	71 19 5	71 19·5
Valentia . .	— 12	S. 2	1	71 5 4	71 5·4
Dingle	— 18	S 2	1	71 8 1	71 8·1
Tulla .	Dec 10	S 2	1	71 26 9	71 26 9
Limerick	— 26, 27	S 2	3	71 5·0	71 5 0
Youghal	— 29	S. 2	2	70 39·4	70 39·4
Limerick . .	Feb. 1836	S 2	1	71 3·8	71 3·8
——	May	S. 2	2	71 2·4	71 1·1
——	May	S. 1	1	71 0·6	
——	May, June	M	2	71 0·0	
Dublin	April, May	L. 3	4	71 3·0	71 3·5
——	April, May	L 4	4	71 4·0	
——	July 22, 23	S. 2	3	71 3 5	71 3·5
——	Aug 5, 6	L. 3	2	71 1 8	71 1·2
——	Aug 5, 6	L. 4	2	71 0·6	
Bangor .	Sept 21	S. 2	1	71 39 1	71 39·1
Dublin . .	Oct. 4	S 2	1	71 3·1	71 3·1
——	Aug. 3—7, 1838	G. 2	9	70 54·6	70 54·6
——	Sept. 25, 26	D. 1	3	70 56 3	70 57·0
——	Sept 27—Oct 2	D. 2	6	70 58·7	

The following table contains the final mean dip at each station, reduced to a common epoch, (the 1st January, 1837,), and the latitudes and longitudes of the stations:

TABLE XXXVII.

Station	Lat.	Long	Dip	Station	Lat	Long	Dip
	° ′	° ′	° ′		° ′	° ′	° ′
Causeway .	55 15	6 31	73 11·8	Colerain ..	55 8	6 40	71 21·6
Belmullet .	54 13	9 57	72 10·2	Tulla . ..	52 52	8 43	71 17·5
Ballina .	54 7	9 7	72 5·8	Ballybunan	52 30	9 41	71 16·8
Puntoon ...	53 58	9 10	72 4·8	Ennis	52 51	8 58	71 10·0
Markree ...	54 12	8 26	72 3·1	Dingle ...	52 8	10 17	71 5·4
Achill	53 56	9 52	72 3·3	Valentia	51 56	10 17	71 2·7
Westport...	53 48	9 29	71 59·8	Limerick ..	52 40	8 35	71 1·8
Cushendall	55 4	6 5	71 56·8	Dublin .	53 21	6 16	71 1·2
Carn	55 15	7 15	71 55·6	Killarney	52 3	9 31	70 59·1
Enniskillen	54 21	7 38	71 54·8	Glengariff .	51 45	9 31	70 56·1
Strabane ..	54 49	7 28	71 51·8	Gorey .. .	52 40	6 17	70 52·6
Clifden ...	53 29	9 59	71 48·8	Rathdrum .	52 55	6 14	70 50·3
Bangor ...	54 39	5 42	71 38·5	Waterford .	52 16	7 8	70 47·3
Galborich .	53 25	9 5	71 37·8	Fermoy ...	52 7	8 16	70 43·3
Armagh ...	54 21	6 39	71 36·0	Cork	51 54	8 26	70 39·9
Galway ...	53 17	9 4	71 26·3	Youghal..	51 57	7 50	70 37·0
Carlingford	54 2	6 11	71 25·0	Broadway .	52 13	6 24	70 32·7

Of the foregoing results, those obtained at the Giants' Causeway and at Colerain are manifestly affected, to a very considerable extent, by the disturbing action of the basaltic rocks. The effect of the basaltic pillars of the Causeway upon the magnetic needle has been long since observed; and on comparing the dip recorded in the preceding table, with that due to the geographical position of the station, we find it in excess to the amount of 50′. At Colerain, on the other hand, the effect of the disturbing action has been to diminish the dip, but in a less amount. The cause of these irregularities being apparent, we have no hesitation in rejecting the results, in the computation of the the isoclinal lines.

Before we proceed to this computation, we must estimate the *weights* of the observed results; and for this purpose it is necessary to know the amount of the probable error of station. This is obtained by computing (with assumed approximate values of L,M,N,) the probable dip at each station, due to its geographical position, and comparing it with that observed. The sum of the squares of the differences of the computed and observed results, substituted in (12), will give the *total* mean probable error, from which (the errors of *observation* and of *instrument* being already known) the *local* error is deduced by means of the equation (17).

Now assuming the approximate values

$$L = 71^\circ\ 22'\ 5, \quad M = +{\cdot}30, \quad N = +{\cdot}51\ ,$$

the probable dip at each station will be given by the formula

$$z = 71^\circ\ 22'{\cdot}5 + {\cdot}30\ x + {\cdot}51\ y\ ;$$

and the computation gives for the sum of the squares of the differences of the computed and observed results, at the 32 stations,

$$\Sigma\,(x - a)^2 = 1192\ 09\ ;$$

from which we find (12)

$$E^2 = 17{\cdot}18, \quad E = 1{\cdot}2,$$

E denoting the total probable error at any one station. But if E_o and E_i denote the *mean* probable errors of observation and of instrument at each station, and E_l the probable local error,

$$E^2 = E_o^2 + E_i^2 + E_l^2.$$

For the observations of this series, $E_o = E_i = 2{\cdot}0$*, wherefore

$$E_l = 3'{\cdot}1.$$

To deduce the weight of the result of n_o observations, with n_i instruments, at any station, we substitute the values thus obtained in (17), and we obtain

$$\frac{1}{w} = 4\left(\frac{1}{n_o} + \frac{1}{n_i}\right) + 9.$$

When the local error, therefore, bears so great a proportion to the errors of observation and of instrument, as it does in the present instance, it is manifestly waste of labour (as far as regards the determination of the position of the isoclinal lines) to multiply observations at any one station. In the case under consideration, the weight due to the result at any station (however the observations be multiplied, and whatever the number of instruments employed) can never amount to double the weight of a single observation

Substituting the values of n_o and n_i in the preceding formula, we find the weight of the mean dip, in Dublin and Limerick, equal to 1·8, the weight of a single observation being unity: in no other case throughout this series does the weight amount to more than 1·3. Taking the nearest whole numbers for the value of this ratio, we shall assign a weight of 2 to Dublin and

* Throughout a considerable portion of the series, two needles, L 1 and L 4, were used together The probable error of *observation* of the mean is nearly 2′, the *instrumental* error is little less than that of a single needle, being, in this case, due chiefly to the magnetism of the limb

to Limerick, the weight of each of the other stations being unity. The results of the calculation are the following:

$$L = 71^\circ\ 22'{\cdot}74, \quad M = +{\cdot}300, \quad N = +{\cdot}505.$$
$$u = -\ 59^\circ\ 16', \quad r = {\cdot}587.$$

Accordingly, the dip at the central station (latitude $= 53^\circ\ 21'$, longitude $= 8^\circ\ 0'$) is $71^\circ\ 22'{\cdot}7$; the epoch being the 1st January, 1837.

Captain Ross's Observations of Dip in Ireland.

These observations were made at 12 stations, with the needles already designated as R. 4, R. 5, R. 6, R. 7. They are contained in the following table.

TABLE XXXVIII.

Station	Date	Hour.	Needle	Poles. α direct, β reversed.	Observed Dip	Mean Dip	Place of Observation.
Waterford	1838. Oct. 4	1·0 P.M.	R 6	α 70 43·4			
				β 70 50·4	70 46 9		
		3·15 P.M.	R 4	α 70 44·3		70 45·8	In an Orchard, ¼ mile mag. S. of the Church
				β 70 45 1	70 44·7		
Cork....... ...	— 6	1·45 P.M.	R 6	α 70 36·6			
				β 70 42	70 39·3		
		3·20 P.M.	R 4	α 70 34·5			
				β 70 38·3	70 36 4		
	— 7	2·15 P.M.	R 7	α 70 41·7		70 39·4	In Mr. Jones's nursery grounds.
				β 70 41·7	70 41·7		
		2·30 P.M.	R 5	α 70 36·6			
				β 70 43·4	70 40		
Valentia Island.	— 12	2·30 P.M	R 6	α 70 50·2			
				β 70 54·4	70 52·3		
	— 13	1·0 P.M.	R 4	α 70 51 5			
				β 70 52·1	70 51·8	70 52	Near the N W. point of the Island.
		2·30 P.M.	R 5	α 70 50·2			
				β 70 53·6	70 51·9		
Killarney......	— 17	1·30 P.M.	R 6	α 70 49·3			
				β 70 55·9	70 52·6		
	— 19	11 20 A.M	R 4	α 70 49·6			
				β 70 49 6	70 49·6	70 51·1	In the grounds of Mucruss, near the Abbey, the demesne of H. Arthur Herbert, Esq.
		3 0 P.M.	R 5	α 70 50 2			
				β 70 53·6	70 51·9		
Limerick......	— 22	2·30 P.M.	R 6	α 70 58·2			
				β 71 1·8	71 0		
		4·0 P.M.	R 4	α 70 58·4			
				β 70 58·4	70 58·4		
	— 23	1·0 P.M.	R 5	α 71 1		70 59·6	In the garden of Somerville, the seat of James Hervey, Esq.
				β 70 59·7	71 0·4		
		2·45 P.M.	R 7	α 70 59·7			
				β 70 59·6	70 59·6		
Shannon Harbour.	— 26	11 20 A.M	R 6	α 71 19			
				β 71 25 4	71 22·2		
		1·0 P.M	R 4	α 71 25·5		71 23·2	In the garden of Faulkner's Inn.
				β 71 22·7	71 24·1		

Station	Date	Hour	Needle	Poles α direct, β reversed	Observed Dip	Mean Dip	Place of Observation
Dublin	1838 Oct 29	1 0 P M	R 6	α 70° 58′ 2		70° 59′ 8	Near the Magnetic Observatory in the Gardens of Trinity College
				β 71 4 2	71° 1′ 2		
		2 0 P M	R 7	α 70 59 4			
				β 71 1 4	71 0 4		
		2 45 P M	R 4	α 70 59 8			
				β 71 0 2	71 0		
		4 0 P M	R 5	α 70 56 6			
				β 71 0 8	70 58 7		
	— 30	Noon	R 6	α 70 57			
				β 71 1 3	70 59 1		
		1 30 P M	R 4	α 70 57 8			
				β 71 0 6	70 59 2		
Armagh	Nov 2	11 0 A M	R 6	α 71 38 4		71 40 5	In the garden North of the Observatory
				β 71 42 4	71 40 4		
		0 30 P M	R 4	α 71 39 7			
				β 71 40 3	71 40		
		2 20 P M	R 5	α 71 41 1			
				β 71 41	71 41 1		
Londonderry	— 5	1 30 P M	R 4	α 72 4 7		72 2 3	In an orchard, S W by S true 1½ a mile from the Cathedral
				β 72 0 5	72 2 6		
		4 0 P M	R 6	α 72 2 6			
				β 72 3 7	72 3 2		
	— 6	2 30 P M	R 5	α 72 1 7			
				β 72 0 7	72 1 2		
Sligo	— 10	0·40 P M	R 6	α 72 0		72 0 2	In the grounds of Markree Castle the demesne of E J Cooper, Esq, M P
				β 72 0 6	72 0 3		
		2 30 P M	R 4	α 72 2 2			
				β 71 58 2	72 0 2		
Westport	— 13	1 30 P M	R 6	α 71 57 8		71 59	In the garden of the Hotel
				β 71 58 8	71 58 3		
		3 10 P M	R 4	α 72 1 0			
				β 71 58 4	71 59 7		
Edgeworths-town	— 19	1 15 P M	R 6	α 71 27 6		71 29 8	In the garden of the residence of the Edgeworth family
				β 71 32 6	71 30 1		
		3 15 P M	R 4	α 71 29 2			
				β 71 29 9	71 29 6		

The next table contains the latitudes and longitudes of Captain Ross's Irish stations, and the mean dip at each station The observations were made in such quick succession that the reduction to a mean epoch is unnecessary

TABLE XXXIX.

Station	Lat.	Long	Dip	Station	Lat	Long	Dip
Londonderry	55° 0′	7° 20′	72° 02′ 3	Dublin	53° 21′	6° 16′	70° 59′ 8
Markree	54 12	8 26	72 00 2	Limerick	52 40	8 35	70 59 6
Westport	53 48	9 29	71 59	Valentia	51 56	10 17	70 52
Armagh	54 21	6 39	71 40 5	Killarney	52 03	9 31	70 51 1
Edgeworth's-town	53 42	7 33	71 29 8	Waterford	52 16	7 08	70 45 8
Shannon Harbour	53 14	7 52	71 23 2	Cork	51 54	8 28	70 39 4

The foregoing observations having been made with different needles in the same circle, it becomes necessary, in estimating the probable error, to separate those due to the limb from those which arise from irregularities in the axle. From the mode in which the observations were taken,—namely (in all but one instance) a *single* observation with each needle,—the *axle error* and the error of observation are combined; and the beautiful accordance of the partial observations shows that their combined result is inconsiderable. There seems reason, however, for believing that the circle itself is not free from error. The mean result obtained with these needles, in this circle, at Westbourne Green, is 2′·0 *less* than the mean of the other needles employed at the same place (see Table III.); while on the other hand, they give a result 3′·8 *in excess* of the mean dip, as shown by Gambey's needles in Dublin,—the latter being observed by the method of arbitrary azimuths.

Now the total probable error at each station, in this series, (as deduced from a comparison of the computed and observed results) is found to be 4′·0,—a result scarcely differing from that of the former series. Of this, the part which is reduced by repetition is (as has been already stated) exceedingly small, and, consequently, the remainder (the combined result of the station and circle errors) is considerable. Under these circumstances, it will be readily seen, no disproportion in the number of observations can materially alter the weights, and as, in addition to this, the observations have been distributed with some attention to uniformity, it is manifest that we must regard the weights of all the stations as equal.

The results of calculation are

$$L = 71^\circ\ 22'\cdot 0,\quad M = +\cdot 270,\quad N = +\cdot 550$$
$$u = -63^\circ\ 49',\quad r = \cdot 613.$$

Hence the dip at the central station, on the 1st November, 1838, was 71° 22′·0, the central station being the same as before; consequently, the probable dip at that station, on the 1st January, 1837, was 71° 26′·4.

Finally, if we combine these results with those of the former series, allowing weights in proportion to the number of stations, we find

$$L = 71^\circ\ 23'\cdot 7,\quad M = +\cdot 292,\quad N = +\cdot 517$$
$$u = -60^\circ\ 32',\ r = \cdot 594;$$

L denoting the mean dip at the central station, on the 1st January, 1837.

Report resumed by Major Sabine.

To the observations in Ireland I have to add a very careful determination of the dip at Lissadel in the county of Sligo, the seat of Sir Robert Gore Booth, Bart., made at my request with Captain Fitz Roy's Gambey by Archibald Smith, Esq., of Jordan Hill.

TABLE XL.

Lat	Long	Date	Hour	Needle.	Poles α direct β reversed.	Mean	Mean Dip
° ′	° ′	1838.			° ′	° ′	° ′
54 23	8 33	Sept 19	Noon	2	α 71 57·5 β 71 57·6	71 57·6	71 56
		— 22	2 P.M.	2	α 71 54·4 β 71 55·3	71 55	
		— 24	9½ A.M.	2	α 71 54·5 β 71 56	71 55·2	
		— 25	9½ A.M.	2	α 71 54·5 β 71 57·8	71 56·2	

Collecting in one view the values of u and r obtained from the observations in Ireland, we have as follows:—

TABLE XLI.

Observer.	No. Stations.	Cent. Geog. Posit. Lat.	Cent. Geog. Posit. Long.	Values of u	Values of r
Lloyd, Fox, and Sabine	34	53 21	8 0	59 16	0·578
Ross	12	53 21	8 0	63 40	0·643

Regarding the values of u and r as entitled to weight, proportioned to the number of stations, of which each is the representative, we obtain — 60° 32′ and 0′·594 as the mean values derived from the Irish series, and corresponding to the mean geographical position, 53° 21′ N. and 8° 00′ W.

Collecting in one view the values of u and r at the central geographical positions in England, Scotland and Ireland, as they have been derived from the several series in each country, we have as follows:

England,	Lat. 52° 38′.	Long. 2° 07′;	$u = -65° 05′$;	$r = 0{\cdot}575′$
Scotland,	— 56° 49′.	— 3° 39′;	$u = -56° 06′$;	$r = 0{\cdot}549′$
Ireland,	— 53° 21′.	— 8° 00′;	$u = -60° 32′$;	$r = 0{\cdot}594′$

Whence it appears that the isoclinal lines do not intersect the geographical meridian at the same angle in the three countries; that they form a greater angle with the meridians in England than in either of the other two countries; and that the angle is also greater in Ireland than in Scotland.

It also appears that the distance between the lines is greatest in Scotland, less in England, and least in Ireland; the number of geographical miles, measured on the perpendicular, corresponding to differences of a degree of dip,—being

109·2 in Scotland;
104·4 in England;
101·0 in Ireland.

It follows, from the different values of r, that the assumption, upon which we have hitherto proceeded in these combinations, of parallelism of the lines and their equidistance apart, does not hold good when applied to an area of the extent of the British islands, and not *strictly* so for any of its three portions; and that it is desirable to find a method of more exactly representing the observations, by tracing each isoclinal line separately from observations nearly of its own value, and consequently but little removed from it in geographical distance. If we have the approximate values of u and r at any station where the dip has been observed, we may readily compute the latitude and longitude of a point furnished by that observation for the position of the next adjacent isoclinal line. If the isoclinal lines sought are those of complete degrees (*i.e.* the lines of 69° 00′, 70° 00′, 71° 00′, &c.), and if the observation be also without fractional minutes—say, for example, 69° 00′—the point furnished by that observation for the line of 69° 00′ is at the station itself. If the observation exceeds or falls short of 69° 00′ by a few minutes, the point furnished by it for the isoclinal line must be distant from the station a geographical space, equivalent to the value in distance of the fractional minutes, as computed by the value of r, and in the direction of $u + 90°$. Thus, if D be the degree of dip represented by the iso-

clinal line, δ the dip observed at a station, of which the latitude is λ, then is $(D-\delta)\frac{\sin u}{r}$ the difference of latitude, and $(D-\delta)\frac{\cos u}{r}\sec\lambda$ the difference of longitude, between the station and the point which it furnishes for the isoclinal line.

We have the values of u and r at the central geographical positions in England, Ireland, and Scotland, as derived from observation If, for a general central station in the British Islands, we take the mean of the central stations in the three countries, viz. lat $54^\circ 16'$ N., long. $4^\circ 35'$ W., we may deduce the values of u and r for that station from equations of the form

$$u_{,} = u + a_{,}x + b_{,}y$$
$$r_{,} = r + a_{,}x + b_{,}y,$$

where $u_{,}$ is the angle and $r_{,}$ the rate of increase at one of the three central geographical positions; $a_{,}$ and $b_{,}$ co-ordinates of distance in longitude and latitude from the general central station, expressed in geographical miles; and x and y coefficients of the change in the values of u and r in each geographical mile, y in the direction of the meridian, and x in that of the perpendicular thereto. The mean results in the three countries will then furnish respectively the three following equations for the value of u,

$$\text{England, } 3905' = u - 89\,x - 98\,y;$$
$$\text{Scotland, } 3366' = u - 34\,x + 153\,y;$$
$$\text{Ireland, } 3632' = u + 123\,x - 55\,y;$$

The number of stations from which the mean results were obtained was,

$$\left.\begin{array}{ll}\text{In England,} & 122\\ \text{In Scotland,} & 46\\ \text{In Ireland,} & 39\end{array}\right\}\ \text{or nearly in the proportion of}\ \left\{\begin{array}{l}3\\1\\1\end{array}\right.$$

In combining these equations therefore by the method of least squares, to obtain the most probable values of u, x, and y, we may give the weight of 3 to the English result, and that of unity to each of the two others.

Pursuing the usual process, we derive $u = -60^\circ 42'$; $x = +0{\cdot}6$, $y = +2\,0$. and we may compute the approximate value of u at any geographical position in the British Islands, by the formula

$$u = -60^\circ 42' + 0{\cdot}6\,a + 2\,b,$$

the origin of the coordinates, a and b being the general central station in 4° 35′ W longitude, and 54° 16′ N latitude

Proceeding in the same manner for r, we have the 3 equations:

$$\begin{array}{ll} \text{England,} & +0\cdot575 = r - 89\,x - 98\,y, \\ \text{Scotland,} & +0\cdot549 = r - 34\,x + 153\,y, \\ \text{Ireland,} & +0\cdot594 = r + 123\,x - 55\,y \end{array}$$

Giving the English result the weight of 3, and each of the others that of unity, and deducing by the method of least squares the most probable values of r, x, and y, we obtain $x = +\cdot00007$; $y = -\cdot00013$, and $r = 0\cdot571$, at the central general station in lat 54° 16′ and long 4° 35′ W.

Whence the approximate value of r is found at any other geographical position in the British Islands by the formula

$$r = +0\cdot571 + \cdot00007\,a - \cdot00013\,b,$$

the longitude and latitude of the general central station being the origin of the coordinates a and b.

The points furnished by the several observations for the nearest adjacent isoclinal line, computed in the manner above described, are inserted in the general table which closes this division of the report The table is in two parts, the one containing the observations, the other the deductions In the first part are shown the observed dip, the latitude and longitude of the station, the date, the observer, and a reference to the particular table in which all the details connected with the observations may be examined. In the division which contains the deductions, are shown the dip reduced to the mean epoch of the 1st January, 1837; the differences of latitude and longitude between the station and the point furnished by it for the nearest isoclinal line; the latitude and longitude of the points, and the values of u and r, employed in their deduction

By the method thus described, the transfer of the observation to the isoclinal line involves no other material inaccuracy than such as may be occasioned by incorrectness in the employed values of u and r We may, therefore, examine the probable limit of the inaccuracy which may be thus incurred,—30 minutes of dip is the extreme fractional amount in any case for which a deduction is required if we suppose an error in the assumed value of r equal to 0·01, which is nearly a fourth of the extreme difference found for England, Ireland and Scotland,—the corresponding error in the geographical distance of the point from the station will be less than one mile An error of 1° in the value of u, in the same extreme case of a fractional amount of 30′ of dip, would cause an error in the position as-

signed to the point of less than one mile in latitude, and half a mile in longitude We may hence estimate the probable limits of inaccuracy in the extreme cases alluded to It is obvious that when the fractional minutes in the observation are less than thirty, these limits are proportionally reduced, and it is further plain that errors thus occasioned will be of a contrary nature to each other, according as the fractional minutes are in excess or in defect of the degree which the line represents When, therefore, the observations are numerous, and fall on both sides of the lines, as is the case in this survey, a mutual compensation is afforded, and whatever small inaccuracies there may be in the values of *u* and *r*, their ultimate effect on the lines may be regarded as wholly insensible

If the observations at each station were free from instrumental defect and local influence,—and if they were continued sufficiently long at each station to furnish its mean dip independent of diurnal and irregular fluctuations,—the points computed from them and transferred to a map would require merely to be connected in order to form the isoclinal line As might be expected, however, the results of the observations are far from presenting this perfect accordance, especially in Scotland, where the prevalence of igneous rocks produces much disturbing action. An examination of the map, however, in which the points, and the stations they are derived from, are inserted, will show that, notwithstanding the disturbing causes referred to, they do arrange themselves in such manner as to leave very little uncertainty in any quarter in tracing the position and direction of each isoclinal line. Each line thus becomes an independent determination, derived from observations which belong to itself alone, and uninfluenced by those which differ more than thirty minutes from the degree which the line represents*.

By this method of combination, any departure from systematic arrangement which might exist in any one of the lines passing across the British Islands, would become manifest at once to the eye Individual stations there are, particularly in Scotland and the north of Ireland, which throw their points to some distance from their respective lines In some very few cases, a group of neighbouring stations appears to be similarly affected The most prominent instance of this is in North Wales, where there appears a decided disposition of the majority of the

* This has been strictly adhered to in the table everywhere, and in the map everywhere over the surface of the land The lines are extended in the map a short distance *beyond* the land, and as the observations which justify this extension are few in comparison with those in other parts of the map, the determinations which fall nearly midway between two lines have, in these few cases, been given a bearing on the lines on either side of them

points to fall to the south of the line of 71°, contrasted with and counterbalanced by an opposite tendency of the points furnished for the same line on the east of Ireland* A more extensive research is necessary to determine whether, by multiplying the number of stations in these localities, this apparent irregularity would disappear, or whether the observations referred to truly represent what may be termed a district anomaly. Whilst, however, on minute examination the eye may rest on single stations, or on groups, which present examples of the slight irregularities here referred to, it cannot fail, on the general aspect of the map, to be struck by the absence of any important unsymmetrical inflections, and by the obvious general systematic arrangement of the terrestrial magnetism indicated by the lines. Here, as elsewhere, they present the features of the general magnetic system; the effects of local and partial disturbance being indeed discernible on close examination, but not being found of sufficient comparative magnitude to influence the general representation.

The lines of dip as they appear on the map are slightly curved, being convex towards the S.E. If the extreme points of each line were connected by an arc of a great circle, the curvature of the arc, on the projection which is here employed, would be in the opposite direction to that of the isoclinal lines, or the convexity would be towards the N W Their departure from such a straight line on the surface of the globe (or their difference from great circles) is greater therefore than appears in this projection

* This apparent dislocation of the line of 71° between England and Ireland was noticed by Mr Fox in the Report of the Royal Cornwall Polytechnic Society for 1835 No trace of a corresponding irregularity occurs in the continuity of the line 72° in crossing the Irish Channel

GENERAL TABLE DIP.

OBSERVATIONS — Dips from 73° 30′ to 72° 30′							DEDUCTIONS.		Corresponding points in the Isoclinal line of 73°				
Station	Lat	Long	Date	Observer	Table	Dip	Reduction to Epoch	Dip at the Mean Epoch, 1 Jan 1837	Δ Lat	Δ Long	The line of 73° in Lat	The line of 73° in Long	Values employed of u and r
	° ′	° ′				° ′		° ′	′	′	° ′	° ′	
Lerwick*	60 09	1 07	July 24–27, 1838	R	XXII	73 44 9	+3 8	73 48 7					
Aberdeen	57 09	2 05	July 18, 1838	R	XXII	72 27 6	+3 7	72 31 3	+44	+55	57 53	3 00	$u = -55° 75$, $r = 0' 543$
Kirkwall	59 00	2 58	July 31, 1838	R	XXII	73 20 4	+3 8	73 24 2	−36	−55	58 24	2 03	$u = -51° 75$, $r = 0 531$
Wick	58 24	3 05	Aug 8, 1838	R	XXII	73 19 9	+3 9	73 23 8	−35	−49	57 49	2 16	$u = -53° 5$, $r = 0 540$
Gordon Castle	57 37	3 09	— 25, 1836	S	XXIV	72 40 7	−0 8	72 40 0	+31	+40	58 08	3 49	
Golspie	57 58	3 57	— 23, 1836	S	XXIV	72 55 5	−0 8	72 54 7	+ 8	+10	58 06	4 07	
Golspie	57 58	3 57	— 10, 1838	R	XXII	73 04 3	+3 9	73 08 2	−12	−17	57 46	3 40	
Inverness	57 28	4 11	— 20 & 24, 1836	S	XXIV	72 46 4	−0 9	72 45 5	+21	+28	57 49	4 39	$u = -54° 5$, $r = 0' 546$
Inverness	57 28	4 11	— 13–14, 1838	R	XXII	72 46 2	+3 9	72 50 1	+14	+19	57 42	4 30	
Fort Augustus	57 08	4 40	— 19, 1836	S	XXIV	72 40 3	−0 9	72 39 4	+31	+38	57 39	5 18	$u = -55° 75$, $r = 0' 550$
Artornish	56 33	5 48	— 16, 1836	S	XXIV	72 42 8	−0 9	72 41 9	+27	+34	57 00	6 22	$u = -54° 75$, $r = 0 553'$
Tobermorie	56 38	6 01	— 10, 1836	S	XXIV	73 07 6	−0 9	73 06 7	−10	−13	56 28	5 48	
Loch Slapin	57 14	6 02	— 14, 1386	S	XXIV	73 02 1	−0 9	73 01 2	− 2	− 3	57 12	5 59	
Loch Scavig	57 14	6 07	— 12, 1836	S	XXIV	73 05 2	−0 9	73 04 4	− 7	−10	57 07	5 57	

* The Dip at Lerwick 73° 48′ 7 belongs to the Isoclinal line of 74°, and is the only dip exceeding 73° 30′

OBSERVATIONS							DEDUCTIONS						
	Dips from 72° 30′ to 71° 30								Corresponding points in the Isoclinal line of 72°				
Station	Lat	Long	Date	Observer	Table	Dip	Reduction to Epoch	Dip at the Mean Epoch, 1 Jan 1837	Δ Lat	Δ Long	The line of 72° in Lat	The line of 72° in Long	Values employed of u and r
	° ′	° ′				° ′	′	° ′	′	′	° ′	° ′	
Berwick	55 45	2 00	Sept 17 & 18, 1838	R	XXII	71 41 9	+4 1	71 46 0	+22	+24	56 07	2 24	$u=-58°\ 75$, $r=0'\ 555$
Dryburgh	55 34	2 39	— 7, 1836	S	XXIV	71 33 6	−0 8	71 32 8	+42	+45	56 16	3 24	
Melrose	55 35	2 44	— 6, 1836	S	XXIV.	71 36 8	−0 8	71 36 0	+37	+40	56 12	3 24	
Melrose ..	55 35	2 44	Aug 26, 1837	F	XXV	71 38 0	+1 6	71 39 6	+31	+34	56 06	3 18	
Alford	57 13	2 45	— 27 & 29, 1836	S	XXIV	72 21 9	−0 8	72 21 1	−32	−41	56 41	2 04	$u=-55°\ 25$, $r=0'\ 544$
Rhynie	57 20	2 50	— 26, 1836	S	XXIV	72 25 6	−0 8	72 24 8	−38	−48	56 42	2 02	
Carlisle	54 54	2 54	Sept 29, 1837	P	XIII	71 28 5	+1 8	71 30 3	+46	+46	55 40	3 40	$u=-59°\ 75$, $r=0'\ 562$
Newport	56 25	2 55	— 1, 1836	S	XXIV	72 17 4	−0 8	72 10 1	−15	−17	56 10	2 38	$u=-57°\ 0$, $r=0'\ 550$
Gretna Green	55 01	3 04	— 6, 1837	F	XXV	71 29 0	+1 4	71 30 4	+46	+46	55 47	3 50	$u=-59°\ 75$, $r=0'\ 562$
Kirkaldy	56 07	3 09	— 3, 1836	S	XXIV	72 10 9	−0 8	72 10 1	−15	−17	55 52	2 52	$u=-57°\ 75$, $r=0'\ 555$
Edinburgh	55 57	3 11	— 8 1836	S	XXIV	71 50 3	−0 9	71 49 4	+16	+18	56 13	3 29	
Edinburgh	55 57	3 11	Aug 28, 1837	F	XXV	71 50 0	+1 6	71 51 6	+13	+15	56 10	3 26	
Blairgowrie	56 36	3 18	— 31, 1836	S	XXIV	71 54 7	−0 8	71 53 5	+10	+12	56 46	3 30	
Braemar	57 01	3 25	— 30, 1836	S	XXIV	72 14 1	−0 8	72 13 3	−20	−25	56 41	3 00	$u=-55°\ 5$, $r=0'\ 547$
Moffat	55 20	3 27	— 6, 1837	F	XXV	71 40 0	+1 6	71 41·6	+28	+30	55 48	3 57	$u=-59°\ 0$, $r=0'\ 560$
Dunkeld	56 35	3 33	Sept 20 & 21, 1838	R	XXII	72 23 1	+4 1	72 27 2	−41	−49	55 54	2 44	$u=-56°\ 5$, $r=0'\ 551$
Linlithgow	55 59	3 37	— 30, 1837	F	XXV	71 59 0	+1 6	72 00 6	− 1	− 1	55 58	3 36	
Culgruff	54 58	4 00	— 8, 1838	R	XXII	71 35 7	+4 1	71 39 8	+31	+32	55 29	4 32	$u=-59°\ 5$, $r=0'\ 564$
Glasgow	55 51	4 14	— 9, 1836	S	XXIV	72 01 6	−0 7	72 00 9	− 1	− 1	55 50	4 13	$u=-57°\ 5$, $r=0'\ 558$
Glasgow	55 51	4 14	— 4, 1837	F	XXV	72 05 0	+1 6	72 06 6	− 9	−10	55 42	4 02	
Jordan Hill	55 54	4 21	— 13 & 14, 1838	R	XXIV	72 20 0	+4 1	72 24 1	−36	−41	55 18	3 40	
Jordan Hill...	55 54	4 21	— 11–14 1838	S	XVII	72 14 3	+4 1	72 18 4	−28	−32	55 26	3 49	

Loch Lomond	56° 13′	4° 40′	Sept. 1,	1837	F	XXV	72° 15′·0	+1′ 6	72° 16′ 6	−25′	−29′	55° 48′	4° 11′	$u=-57°·0$
Helensburgh	56 00	4 41	July 2&8 Sept. 13,	1836	S	XXIV	72 16 7	−0 9	72 15 8	−24	−28	55 36	4 13	$r=0'557$
Helensburgh	56 00	4 41	Sept. 10,	1838	S	XVII	72 17·0	+4 1	72 21 1	−32	−37	55 28	4 04	
Cumbray	55 48	4 52	July 30,	1836	S	XXIV	72 01 1	−1·0	72 00·1	0	0	55 48	4 52	$u=-59° 0$
Loch Ryan	54 55	4 59	Sept. 18,	1836	S	XXIV	71 43 3	−0 7	71 42·6	+26	+27	55 21	5 26	
Inverary	56 15	5 04	Aug 31,	1837	F	XXV	72 07·0	+1 6	72 08 6	−14	−15	56 01	4 49	$u=-58° 5$
Glencoe	56 39	5 07	— 17,	1836	S	XXIV	72 17·1	−0·9	71 16·2	−25	−28	56 14	4 39	$r=0'·557$
Loch Ridan	55 57	5 10	— 5,	1836	S	XXIV	72 16·6	−1·0	72 15·6	−24	−27	55 33	4 43	
Loch Ranza	55 42	5 17	Sept. 16,	1836	S	XXIV.	72 22·9	−0·7	72 22·2	−33	−38	55 09	4 39	$u=-57° 5$
Loch Gilphead	56 04	5 28	Aug 7,	1836	S	XXIV	72 07·6	−1·0	72 06·6	−10	−12	55 54	5 16	$r=0' 562$
Campbeltown	55 23	5 38	Sept. 16,	1836	S	XXIV	71 55·9	−0·7	71 55·2	+ 6	+ 7	55 29	4 45	
Bangor	54 39	5 42	Sept. 21,	1836	S	XXXVI	71 39·2	−0·7	71 38·5	+32	+33	55 11	6 15	$u=-59° 5$ $r=0 571$
Castle Duart	56 31	5 45	Aug. 9,	1836	S	XXIV.	72 15·2	−0·9	72 14 3	−23	−27	56 08	5 18	$u=-56°·0$
Cushendal	55 04	6 05	Aug. 28,	1835	F	XXXVI	72 00·0	−3·2	71 56 8	+ 4	+ 5	55 08	6 10	$r=0' 558$
Armagh	54 21	6 39	Oct. 14 & 15,	1834	L	XXXVI	71 42·2	−5 3	71 36·9	+37	+35	54 58	7 14	$u=-60°·0$
Armagh	54 21	6 39	Nov. 2,	1838	R	XXXVIII.	71 40·5	+4 4	71 44·9	+23	+22	54 44	7 01	$r=0' 576$
Carn	55 15	7 15	Oct. 21,	1834	L	XXXVI	72 00·9	−5·2	71 55·7	+ 6	+ 7	55 21	7 22	
Londonderry	54 59	7 19	Nov. 5 & 6,	1838	R	XXXVIII	72 02·3	+4 4	72 06·7	−10	−10	54 49	7 09	$u=-58°·25$
Strabane	54 49	7 28	Oct. 23,	1834	L	XXXVI	73 00·0	−5·2	71 54·8	+ 7	+ 7	54 56	7 35	$r=0' 572$
Edgeworthstown	53 42	7 33	Nov. 19,	1838	R	XXXVIII	71 29·8	+4 5	71 34·3	+38	+36	54 20	8 09	$u=-60° 75$ $r=0' 583$
Enniskillen	54 21	7 38	Oct. 24,	1834	L	XXXVI	72 00·0	−5·2	71 54·8	+ 8	+ 9	54 29	7 47	
Markree	54 12	8 26	Aug 21,	1835	L	XXXVI	72 06·3	−3·2	72 03·1	− 5	− 5	54 09	8 21	$u=-59°·25$
Markree	54 12	8 26	Nov. 10,	1838	R	XXXVIII	72 02·0	+4 5	72 06·5	−10	−11	54 04	8 17	$r=-0' 581$
Lissadel	54 23	8 33	Sept. 19–25,	1838	S	XL.	71 56·0	+4·2	72 00·2	0	0	54 23	8 33	
Gallhorich	53 25	9 05	Aug. 19,	1835	F	XXXVI	71 41·0	−3 2	71 37·8	+33	−31	53 58	9 36	$u=-60° 75$ $r=0' 589$
Ballina	54 07	9 07	— 22,	1835	L	XXXVI.	72 11·0	−3 3	72 07 7	−10	−11	53 57	8 56	
Ballina	54 07	9 07	— 25,	1835	F	XXXVI	72 07·0	−3·2	72 03·8	− 5	− 6	54 02	9 01	
Loch Conn	53 58	9 10	— 24,	1835	F	XXXVI	72 08·0	−3·2	72 04·8	− 7	− 7	53 51	9 03	
Westport	53 48	9 29	— 24,	1835	F	XXXVI	72 03·0	−3·2	71 59·8	0	0	53 48	9 29	$u=-59·0$ $r=-0'·583$
Westport	53 48	9 29	Nov. 13,	1838	R	XXXVIII	71 59·0	+4 5	72 03·5	− 5	− 5	53 43	9 24	
Belmullet	54 13	9 57	Aug. 24,	1835	L	XXXVI.	72 13·4	−3·2	72 10·2	−13	−15	54 00	9 42	
Achil Ferry	53 56	9 53	— 25,	1835	L	XXXVI	72 06·5	−3·2	72 03·3	− 5	− 5	53 51	9 47	
Clifden	53 29	9 59	— 22,	1835	F	XXXVI	71 52·0	−3·2	71 48·8	+17	−16	53 46	10 15	$u=-60·2$ $r=0' 590$

Station.	OBSERVATIONS. Dips from 71° 30′ to 70° 30′. Lat.	Long	Date.	Observer.	Table.	Dip.	DEDUCTIONS. Reduction to Epoch.	Dip at the Mean Epoch, Jan. 1, 1837.	Corresponding points in the Isoclinal Line of 71°. Δ Lat.	Δ Long.	The line of 71° in. Lat.	Long	Values employed of u and r.
Flamborough	54° 08′	0° 08′	June 11, 1837	P	XIII.	70° 36′·9	+1′·1	70° 38′·0	+35′	+31′	54° 43′	0° 39′	$u=-62°·25$ $r=0'·560$
Bridlington..	54 06	0 14	May 3, 1838	R	XV.	70 38·8	+3·2	70 42·0	+27	+24	54 35	0 38	
Scarborough	54 17	0 24	June 13, 1837	P	XIII.	70 41·8	+1·1	70 42·9	+25	+23	54 42	0 47	
Scarborough	54 17	0 24	May 1, 1838	R	XV.	70 43·0	+3·2	70 46·2	+21	+18	54 38	0 42	
Whitby	54 29	0 37	June 9, 1837	P	XIII.	70 57·9	+1·1	70 59·0	+ 2	+ 1	54 31	0 38	
York	53 58	1 05	July 1837	P	XIII.	70 48·8	+1·3	70 50·1	+16	+14	54 14	1 19	$u=-62°·5$ $r=0'·565$
York	53 57	1 06	April 28, 1838	R	XV.	70 45·2	+3·2	70 48·4	+18	+16	54 15	1 22	
Wadworth	53 28	1 07	May 9, 1838	R	XV.	70 27·5	+3·3	70 30·8	+46	+38	54 14	1 45	$u=-63°·5$ $r=0'568$
Doncaster	53 31	1 07	June 2, 1837	P	XIII.	70 30·2	+1·0	70 31·2	+46	+37	54 17	1 44	
Hambleton	54 20	1 15	July 7, 1837	P	XIII.	71 04·0	+1·2	71 05·2	− 8	− 7	54 12	1 08	$u=-62°·0$ $r=0'·563$
Osmotherly	54 22	1 18	June 6, 1837	P	XIII.	71 03·2	+1·0	71 04·2	− 6	− 6	54 16	1 12	
Thirsk	54 14	1 21	June 5, 1837	P	XIII.	70 59·2	+1·0	71 00·2	0	0	54 14	1 21	
Sheffield	53 22	1 31	June 17, 1837	P	XIII.	70 29·7	+1·1	70 30·8	+46	+38	54 08	2 09	$u=-63°5$ $r=0'568$
Darlington	54 32	1 33	Aug. 21, 1837	F	XI	71 07	+1·5	71 08 5	−13	−12	54 19	1 21	$u=-61°·25$ $r=0'562$
Studley Park	54 08	1 34	Aug. 14, 1837	F	XI	70 56	+1·5	70 57 5	+ 4	+ 4	54 12	1 38	
Newcastle	54 58	1 38	Sept. 30, 1837	P	XIII.	71 18·1	+1·8	71 19·9	−31	−31	54 27	1 07	$u=-60°·25$ $r=0'·558$
Newcastle	54 58	1 36	Aug. 28, 1838	S	XVII	71 09	+4·0	71 13·0	−20	−20	54 38	1 16	
Newcastle	54 58	1 36	Aug. 28, 1838	R	XV.	71 13	+4·0	71 17·0	−24	−24	54 34	1 12	
Alnwick Castle	55 25	1 42	Aug. 31, 1838	S	XVII	71 22·6	+4·0	71 26·6	−41	−43	54 44	0 59	$u=-59°5$ $r=0'.556$
Belsay	55 07	1 53	Aug. 25, 1837	F	XI.	71 17	+1·6	71 18·6	−29	−29	54 38	1 24	$u=-60°·25$ $r=0'558$
Hull	54 43	2 00	Aug. 19, 1837	F	XI	71 14	+1·5	71 15 5	−24	−24	54 19	1 36	
Manchester	53 28	2 14	Oct. 14, 1836	L	XII.	70 47·7	−0·5	70 47·2	+20	+17	53 48	2 31	$u=-63°25$ $r=0'571$
Stonehouse	54 55	2 44	Sept. 1, 1838	S	XVII.	71 19·5	+4·0	71 23·5	−36	−36	54 19	2 08	$u=-60°·25$ $r=0'558$
Stonehouse	54 55	2 44	Sept. 1, 1838	R	XV.	71 24·1	+4·0	71 28·1	−43	−43	54 12	2 01	
Penrith	54 40	2 45	Sept. 28, 1837	P	XIII.	71 23·4	+1·8	71 25·2	−39	−39	54 01	2 06	
Garstang	53 54	47	Sept. 12, 1837	F	XI	70 59	+1·7	71 00·7	− 1	− 1	53 53	2 46	

	° ′	° ′					° ′	′	° ′	′	′	° ′	° ′	
Busco Bridge	53 39	2 50	Sept. 12,	1837	F	XI	70 45	+1·7	70 46·7	+20	+18	53 59	3 08	$u=-62°\ 75$
Calderstone	53 23	2 53	Aug 12,	1837	P	XIII	70 43·5	+1·5	70 45·0	+22	+20	53 45	3 13	$r-0'\ 572$
Near Liverpool	53 25	2 55	Sept. 23,	1837	F	XI	70 44	+1·8	70 45·8	+21	+19	53 46	3 14	
Bowness	54 22	2 55	Sept. 25,	1837	P	XIII	71 18·4	+1·8	71 20·2	−31	−30	53 51	2 25	$u=-60°\ 75$
Patterdale	54 32	2 56	Sept. 27,	1837	P	XIII	71 19·6	+1·8	71 21·4	−33	−32	53 59	2 24	$r=0'\ 562$
Liverpool	53 25	2 58	Sept. 19,	1837	F	XI	70 39	+1·7	70 40·7	+29	+26	53 54	3 24	
Birkenhead	53 24	3 00	Aug 8,	1836	L	XII	70 49·1	−0·9	70 48·2	+18	+16	53 42	3 16	$u=-62°\ 75$
Birkenhead	53 24	3 00	Aug 26,	1837	P	XIII	70 39·4	+1·6	70 41·0	+29	+25	53 53	3 25	$r=0'{\cdot}572$
Birkenhead	53 24	3 00	Sept. 18,	1837	S	XVII	70 35·1	+1·7	70 36·8	+36	+31	54 00	3 31	
Birkenhead	53 24	3 00	Oct. 1,	1837	R	XV	70 35·7	+1·8	70 37·5	+35	+30	53 59	3 30	
Grassmere	54 27	3 01	Sept. 9,	1837	F	XI	71 13	+1·7	71 14·7	−22	−21	54 05	2 40	
Coniston	54 22	3 05	Sept. 25,	1837	P	XIII	71 19·5	+1·8	71 21·3	−33	−32	53 49	2 33	$u=-63°\ 75$
Keswick	54 37	3 09	Sept. 7,	1837	F	XI	71 14	+1·6	71 15·6	−24	−23	54 13	2 46	$r=0'{\cdot}564$
Skiddaw	54 40	3 09	Sept. 7,	1837	F	XI.	71 15	+1·6	71 16·6	−26	−25	54 14	2 44	
Coed	53 11	3 12	Sept. 20,	1837	P	XIII	70 40·9	+1·7	70 42·6	+27	+23	53 38	3 35	$u=-60°\ 75$ $r=0'\ 579$
Whitehaven	54 33	3 33	Aug 16,	1838	S	XVII	70 10·9	+3·9	71 14·8	−22	−21	54 11	3 12	$u=-60°\ 75$ $r=0'{\cdot}564$
Capelcarig	53 06	3 53	Sept. 3,	1835	F	XI	70 48	−3·2	70 41·8	+23	+20	53 29	4 13	
Llanberris	53 07	4 03	Sept. 1,	1835	F	XI	70 57	−3·2	70 53·8	+ 9	+ 8	53 16	4 11	$u=-63°{\cdot}0$
Bangor	53 14	4 06	Sept. 1,	1835	F	XI.	71 02	−3·2	70 58·8	+ 1	+ 1	53 15	4 07	$r=0'{\cdot}579$
Carnarvon	53 09	4 14	Sept. 1,	1835	F	XI.	70 58	−3·2	70 54·8	+ 8	+ 7	53 17	4 21	
Pwllheli	52 55	4 23	Oct. 14,	1837	R	XV.	70 32·5	+1·9	70 34·4	+36	+30	53 31	4 53	$u=-63°\ 5$ $r=0'{\cdot}581$
Douglas	54 10	4 28	Aug. 17,	1837	P	XIII	71 22·2	+1·5	71 23·7	−37	−32	53 33	3 56	$u=-62°\ 75$
Douglas	54 10	4 28	Sept. 21,	1837	R	XV.	71 20·3	+1·7	71 22·0	−33	−29	53 37	3 59	$r=0'\ 571$
Holyhead	53 19	4 37	Sept. 1,	1835	F	XI.	71 04	−3·2	71 00·8	− 1	− 1	53 18	4 36	$u=-64°\ 5$
Holyhead	53 19	4 37	April 27,	1836	L	XII.	71 08·5	−1·6	71 06·9	−11	− 9	53 08	4 28	$r=0'579$
Castleton	54 04	4 40	Aug 18,	1837	P	XIII	71 22·5	+1·5	71 24·0	−37	−32	53 27	4 08	$u=-62°\ 75$
Peel town	54 13	4 43	Aug. 18,	1837	P	XIII	71 23·9	+1·5	71 25·4	−40	−35	53 33	4 08	$r=0'\ 571$
Carlingford	54 02	6 11	Oct. 13,	1834	L	XXXVI	71 30·2	−5·3	71 24·9	−39	−36	53 23	5 35	$u=-60°\ 75$ $r=0'\ 577$
Rathdrum	52 55	6 14	Sept. 3,	1835	L	XXXVI	70 53·5	−3·2	70 50·3	+15	+13	53 10	6 27	
Dublin	53 21	6 16	Aug., Sep., Oct.	1834	L	XXXVI	71 06·1	−5·3	71 00·8	− 1	− 1	53 20	6 15	$u=-60°\ 75$
Dublin	53 21	6 16	Sep. & Nov.	1835	L	XXXVI	71 04·8	−3·0	71 01·8	− 3	− 2	53 18	6 14	$r=0'{\cdot}577$
Dublin	53 21	6 16	Aug. 17,	1835	F	XXXVI	70 59·0	−3·3	70 55·7	+ 7	+ 6	53 28	6 22	

Station.	OBSERVATIONS. Dips from 71° 30′ to 70° 30′. Lat.	Long.	Date.	Observer.	Table.	Dip.	DEDUCTIONS. Reduction to Epoch	Dip at the Mean Epoch Jan. 1, 1837.	Corresponding points in the Isoclinal Line of 71°. Δ Lat.	Δ Long.	The line of 71° in Lat	Long	Values employed of u and r.
...in............ . ..	° ′ 53 21	° ′ 6 16	Apr & Aug. 1836	L	XXXVI.	° ′ 71 02·3	′ −1·3	° ′ 71 01·0	′ − 2	′ − 1	° ′ 53 19	° ′ 6 15	$u=-62°\ 25$ $r=0'\ 582$
...n	53 21	6 16	July & Oct. 1836	S	*	71 03 3	−0·8	71 02·5	− 3	− 3	53 18	6 13	
...n.........	53 21	6 16	Oct. 29 & 30, 1838	R	XXXVII	70 59·8	+4 4	71 04 2	− 6	− 6	53 15	6 10	
...n......	53 21	6 16	Aug & Sept. 1838	L	XXXVI.	70 56·3	+4·0	71 00·3	0	0	53 21	6 16	
... .	52 40	6 17	Sept. 3, 1835	L	XXXVI.	70 55 8	−3·2	70 52·6	+11	+10	52 51	6 27	
...lway	52 13	6 24	Sept. 2, 1835	L	XXXVI.	70 35·9	−3·2	70 32·7	+40	+31	52 53	6 55	$u=-64°\ 25$ $r=0'\ 596$
...rford	52 15	7 08	Sept. 1, 1835	L	XXXVI.	70 50·5	−3·2	70 47·3	+18	+14	52 33	7 22	
...rford	52 15	7 08	Oct. 4, 1838	R	XXXVIII.	70 45·8	+4·2	70 50·0	+15	+12	52 30	7 20	
...nal	51 57	7 50	Dec. 29. 1835	S	XXXVI.	70 39·4	−2·4	70 37·0	+35	+27	52 32	8 15	
...on Harbour ..	53 14	7 53	Oct. 26, 1838	R	XXXVIII.	71 23·2	+4·4	71 27·6	−41	−37	52 33	7 16	$u=-61°\ 5$ $r=0'\ 587$
...py	52 07	8 16	Dec. 2, 1834	S	XXXVI.	70 48·2	−5·4	70 43·2	+26	+20	52 33	8 36	$u=-64°\ 0$ $r=0'\ 598$
... .	51 54	8 26	Aug. 31, 1835	L	XXXVI.	70 43 1	−3·2	70 39·9	+30	+23	52 24	8 49	
... .	51 54	8 26	Oct. 6–7, 1838	R	XXXVIII.	70 39·4	+4·2	70 43·6	+25	+19	52 19	8 45	
...ick	52 40	8 36	July & Aug. 1834	S	XXXVI.	71 03·5	−5·8	70 57 7	+ 3	+ 3	52 43	8 39	$u=-62°\ 25$ $r=0'\ 593$
...ick	52 40	8 36	July, & Dec. 1835	S	XXXVI.	71 06·1	−2·1	71 03·0	− 5	− 4	52 35	8 32	
...ick.	52 40	8 36	Aug. 29, 1835	L	XXXVI	71 02·9	−3·2	70 59·7	+ 0	+ 0	52 40	8 36	
...ick..	52 40	8 36	Feb. & May, 1836	S	XXXVI	71 01·1	−1·8	70 59·3	+ 1	+ 1	52 41	8 37	
...ick	52 40	8 36	Oct. 22 & 23, 1838	R	XXXVIII.	70 59·6	+4·3	71 03·9	− 6	− 5	52 34	8 31	
...on	52 52	8 43	Oct. , 1834 Dec. , 1835	S	XXXVI.	71 21 3	−3·8	71 17 5	−25	−21	52 27	8 22	
... .	52 51	8 58	Aug 28, 1835	L	XXXVI	71 13·2	−3·2	71 10·0	−15	−13	52 36	8 45	
...y	53 17	9 04	Aug. 19, 1835	F	XXX.	71 26·0	−3 3	71 22·7	−34	−31	52 43	8 33	$u=-61°\ 0$ $r=0'\ 598$
...y	53 17	9 04	Aug. 28, 1835	L	XXXVI.	71 32·9	−3 2	71 29·7	−44	−40	52 31	8 24	
...ney	52 03	9 31	Oct. 4, 1834	S	XXXVI.	71 04·5	−5·4	70 59·1	+ 1	+ 1	52 04	9 32	$u=-63°\ 5$ $r=0'\ 601$
...ney . ..	52 03	9 31	Oct. 17 & 19, 1838	R	XXXVIII.	70 51 1	+4 3	70 55·4	+ 7	+ 6	52 10	9 38	
...riff	51 45	9 31	Sept. 27 & 28, 1834	S	XXXVI.	71 01·5	−5 4	70 56·1	+ 6	+ 5	51 51	9 36	
...unian	52 30	9 41	Nov. 8, 1835		XXXVI.	71 19·5	−2 7	71 16 8	−25	−21	52 05	9 20	$u=-62°\ 5$ $r=0'\ 598$
...ia . . .	51 56	10 17	Nov. 12, 1835	S	XXXVI.	71 05·4	−2·7	71 02·7	− 4	− 4	51 52	10 13	$u=-63°\ 25$ $r=0'\ 603$
...ia	51 56	10 17	Oct. 12 & 13, 1838	R	XXXVIII.	70 52 0	+4 4	70 56·4	+ 5	+ 5	52 01	10 22	
... .. .	52 08	10 17	Nov 18, 1835	S	XXXVI.	71 08 1	−2·7	71 05 4	− 8	− 7	52 00	10 10	

* Sixth Report B A. Scotch Magnetic Report, Table I

OBSERVATIONS.							DEDUCTIONS.							
	Dips from 70° 30′ to 69° 30′								Corresponding points in the Isoclinal Line of 70°					
											The line of 70° in			
Station.	Lat.	Long.	Date.	Observer.	Table.	Dip	Reduction to Epoch.	Dip at the Mean Epoch, Jan. 1, 1837.	Δ Lat.	Δ Long.	Lat.	Long.	Values employed of u and r.
	° ′	° ′				° ′	′	° ′	′	′	° ′	° ′	
…restoffe	52 28	−1 50	May 24, 1838	R	XV	69 29·2	+3·4	69 32·6	+44	+31	53 12	−1 19	u = −66° 5, r = 0′ 575
…mer	52 56	−1 19	May 21, 1838	R	XV	69 46·1	+3·3	69 49·4	+17	+12	53 13	−1 07	u = −65° 5
…n	52 45	−0 25	Oct. 10, 1836	L	XII	69 53·2	−0·5	69 52·7	+11	+ 8	52 56	−0 17	r = 0′ 571
…nbridge	52 13	−0 07	Oct. 8, 1836	L	XII	69 41·5	−0·5	69 41·0	+30	+24	52 43	0 17	u = −64° 5, r = 0′ 568
…nth	53 19	0 0	May 16, 1838	R	XV.	70 19·4	+3·3	70 22·7	−36	−29	52 43	−0 29	u = −64 25, r = 0′ 567
…tingham	52 57	1 [illegible]	May 12, 1838	R	XV.	70 16·3	+3·3	70 19·6	−31	−24	52 26	0 44	u = −65 25
…entry	52 16	1 [illegible]	Sept. 1, 1837	R	XV.	69 41·1	+1·6	69 42·7	+27	+21	52 43	1 29	r = 0′ 576
…tlock	53 08	1 [illegible]	Oct. 12, 1836	L	XII	70 29·2	−0·5	70 28·7	−45	−37	52 23	0 55	u = −65·0
…tlock	53 08	1 [illegible]	Aug. 9, 1837	F	XI	70 19·0	+1·5	70 20·5	−32	−26	52 36	1 06	r = 0′ 572
…mingham	52 28	1 53	July 3, 1837	P	XIII	70 07·2	+1·3	70 08·5	−13	−10	52 15	1 43	
…mingham	52 28	1 5[illegible]	Sept. 4, 1837	R	XV	70 00·5	+1·6	70 01·1	− 2	− 1	52 26	1 52	u = −65·0
…fford	52 48	2 0[illegible]	Sept. 7, 1837	R	XV	70 09·7	+1·6	70 11·3	−18	−14	52 30	1 52	r = 0′ 577
…lvern	52 07	2 19	Sept. 5, 1835	F	XI	70 11·0	−3·2	70 07·8	−12	− 9	51 55	2 10	u = −66·0, r = 0′ 583
…mbe House	51 31	2 [illegible]	July 2, 1838	F	XI	69 32·0	+3·6	69 35·6	+38	−25	52 9	3 00	
…s	51 55	2 [illegible]	Sept. 8, 1835	F	XI	70 0·0	−3·1	69 56·9	+ 5	− 3	52 00	2 [illegible]	
…fton	51 27	2 35	Aug. 29, 1836	L	XII	69 42·6	−0·8	69 41·8	+29	−20	51 56	2 [illegible]	u = −67·0
…fton	51 27	2 35	Oct. 22, 1837	R	XV.	69 34·0	+2·0	69 36·0	+38	−26	52 05	3 01	r = 0′ 587
…epstow	51 38	2 40	Sept. 9, 1835	F	XI.	69 48·0	−3·1	69 44·9	+24	−16	52 02	2 56	
…epstow	51 38	2 40	Aug. 12, 1836	L	XII.	69 47·9	−0·9	69 47·0	+20	−14	51 58	2 54	
…reford	52 04	2 4[illegible]	Aug. 10, 1836	L	XII	70 07·1	−0·9	70 06·2	−10	− 7	51 54	2 37	u = −66·0, r = 0′ 583
…ewsbury	52 43	2 45	April 26, 1836	L	XII.	70 27·6	−1·6	70 26·0	−41	−31	52 02	2 14	u = −64·5
…ewsbury	52 43	2 45	Sept. 19, 1837	S	XVII.	70 24·5	+1·7	70 26·2	−41	−31	52 02	2 14	r = 0′ 577
…thyr	51 43	3 21	Sept. 22, 1837	S	XVIII.	70 03·9	+1·7	70 05·6	− 8	− 6	51 35	3 15	u = −66·5
…	51 57	3 21	Sept. 23, 1837	S	XVIII.	70 03·2	+1·7	70 04·9	− 7	− 5	51 50	3 16	r = 0′ 590

OBSERVATIONS.							DEDUCTIONS.						
	Dips between 70° 30′ and 69° 30′								Corresponding points in the Isoclinal Line of 70°.				
											The line of 70° in		
Station.	Lat.	Long.	Date.	Observer	Table.	Dip.	Reduction to Epoch.	Dip at the Mean Epoch, Jan. 1, 18[illegible]	Δ Lat.	Δ Long.	Lat.	Long.	Values employed of u and r
nraven Castle	° ′ 51 28	° ′ 3 37	Sept. 28, 1837	S	XVII.	° ′ 69 45·7	′ +1·8	° ′ 69 47·5	′ −19	′ +14	° ′ 51 47	° ′ 3 51	$u = -67° 5$, $r = 0·590$
ath	51 40	3 46	Sept. 11, 1835	F	XI.	69 57	−3·1	69 53·9	− 9	+ 7	51 49	3 53	
nsea	51 36	3 55	Oct. 27, 1837	R	XV.	69 46·7	+2·0	69 48·7	−17	+14	51 53	4 09	$u = -67° 5$, $r = 0·595$
erysthwith	52 24	4 05	Sept. 21, 1837	S	XVII.	70 23·5	−1·7	70 25·2	−39	−30	51 45	3 35	
acombe	51 12	4 06	Nov 3, 1837	R	XV.	69 36·9	+2·0	69 38·9	+33	+22	51 45	4 28	$u = -67° 0$, $r = 0·594$
nbroke	51 39	4 54	Oct. 26, 1837	R	XV.	69 55·9	+2·0	69 57·9	− 3	+ 2	51 42	4 56	$u = -67° 5$, $r = 0·608$
scow	49 57	6 18	Aug 30, 1838	F	XI.	69 27·0	+4·0	69 31·0	+44	+28	50 41	6 46	

OBSERVATIONS.							DEDUCTIONS.						
	Dips between 69° 30′ and 68° 30′								Corresponding points in the Isoclinal Line of 69				
											The line of 69° in		
Station.	Lat.	Long.	Date.	Observer	Table.	Dip.	Reduction to Epoch.	Dip at the Mean Epoch, Jan. 1, 18[illegible]	Δ Lat.	Δ Long.	Lat.	Long.	Values employed of u and r
gate	° ′ 51 23	° ′ −1 23	Nov. 9 & 11, 1837	S	XVII.	° ′ 69 02·9	′ +2·1	° ′ 69 05·0	′ − 8	′ − 5	° ′ 51 15	° ′ −1 28	$u = -67° 5$, $r = 0·575$
gate	51 23	−1 23	April 17, 1838	R	XV.	68 57·2	+3·1	69 00·3	0	0	51 23	−1 23	
er	51 08	−1 19	Nov. 2–7, 1837	S	XVII	68 52·3	+2·0	68 54·3	+ 9	+ 6	51 17	−1 13	
wich	51 56	−1 13	May 28 & 29, 1838	R	XV.	69 15·4	+3·4	69 18·8	−30	−20	51 26	−1 33	
bourne	50 47	−0 16	June 20, 1838	F	XI.	68 45·0	+3·5	68 48·5	+18	+11	51 05	−0 05	$u = -69° 25$, $r = 0·586$
don	51 31	0 07	July 27, 1837	S	XVIII.	69 18·6	+1·2	69 19·8	−31	−20	51 00	−0 13	$u = -67° 75$, $r = 0·581$
don	51 32	0 07	Nov 15 & 16, 1837	S	XVII.	69 23·8	+2·1	69 25·9	−41	−27	50 51	−0 20	
don	51 32	0 07	May & June, 1838	F	XI.	69 18·0	+3·4	69 21·4	−34	−22	50 58	−0 15	
hton	50 50	0 08	Sept. 27, 1836	L	XII.	68 49·7	−0·6	68 49·1	+17	+10	51 07	0 18	$u = -69° 25$, $r = 0·586$
ing	51 26	0 10	June 14, 1838	F	XI.	69 14·5	+3·5	69 18·0	−29	−19	50 57	−0 09	

ndon	51 32	0 11	Ap. & Oct.	1836	L	XII.	69 22·7	−1·0	69 21 7	−35	−23	50 57	−0 12	$m = -67°\ 75$, $r = 0·581$
ndon	51 32	0 11	May 30,	1837	P	XIII.	69 20·2	+1·0	69 21·2	−34	−22	50 58	−0 11	
ndon	51 32	0 11	August 10,	1837	R	X	69 20·2	+1·5	69 21·7	−35	−23	50 57	−0 12	
ndon	51 32	0 11	March 28,	1838	P	XIII.	69 18·2	+3 1	69 21·3	−34	−22	50 58	−0 11	
ndon	51 32	0 11	June & July,	1838	R	X	69 14 3	+3·6	69 17·9	−29	−19	51 03	−0 08	
ndon	51 32	0 11	Dec. 4–10,	1838	R	X.	69 14·6	+4 7	69 18·3	−30	−20	51 02	−0 09	
orcester Park	51 23	0 17	October 8,	1838	S	XVII.	69 06·8	+4·3	69 11·1	−18	−12	51 05	0 05	
w	51 29	0 18	October 13,	1838	S	XVII	69 16·5	+4 3	69 20·8	−33	−21	50 56	−0 03	
stwick Park	51 17	0 19	June 16,	1838	F	XI.	69 08·0	+3 5	69 11·5	−19	−12	50 58	0 07	
shey	51 38	0 22	July & Aug.	1837	R	XV.	69 24·5	+1 4	69 25·9	−42	−28	50 56	−0 06	
ilford	51 14	0 34	Dec. 12 & 13,	1837	R	XV	69 05·1	+2 3	69 07·4	−12	− 7	51 02	0 27	
rtington	50 50	0 34	August 15,	1837	R	XV	68 55·9	+1 5	68 57·4	+ 4	+ 3	50 54	0 37	$m = -68°\ 75$, $r = 0·588$
rtington	50 50	0 34	Aug. & Oct.,	1837	S	XVII	68 57·2	+1·6	68 58·8	+ 2	+ 1	50 52	0 35	
uthsea...	50 48	0 58	December 8,	1837	R	XV.	69 00·4	+2·3	69 02·7	− 4	− 2	50 44	0 56	
Clairs......	50 44	1 08	July 19–22,	1837	P	XIII	69 01·2	+1 3	69 02·5	− 4	− 2	50 40	1 06	
de	50 44	1 10	Aug. & Sept.,	1836	L	XII	69 01·3	−0·8	69 00·5	− 1	0	50 43	1 10	
rlborough	51 25	1 42	October 17,	1837	R	XV.	69 25·4	+1·9	69 27·3	−43	−29	50 42	1 14	$m = -67°·5$, $r = 0·586$
isbury.	51 04	1 48	August 13,	1836	L	XII	69 23·1	−0·5	69 22·6	−36	−23	50 28	1 25	$m = -68°·0$, $r = 0·589$
isbury	51 04	1 48	December 5,	1837	R	XV	69 14·5	+2·2	69 16·7	−26	−17	50 38	1 31	
eymouth	50 37	2 27	Dec 2 & 4,	1837	R	XV.	69 06·7	+2·2	69 08·9	−14	− 9	50 23	1 18	
eter.	50 43	3 31	Nov 30,	1837	R	XV.	69 17·3	+2 2	69 19·5	−30	−19	50 13	2 18	$m = -68°·25$, $r = 0'·596$
ymouth	50 23	4 07	Nov. 28 & 29,	1837	R	XV	69 06·2	+2 2	69 08·4	−13	− 9	50 10	3 12	
w Trenchard	50 40	4 10	July 19 & 21,	1838	S	XVII	69 19·0	+3 7	69 22·7	−35	−22	50 05	3 58	
dstow	50 33	4 56	Nov. 14 & 15,	1837	R	XV.	69 25·1	+2 1	69 27·2	−42	−27	49 51	3 48	$m = -68°·0$, $r = 0'·600$
lmouth	50 09	5 06	Nov. 18,	1837	R	XV	69 16·1	+2 1	69 18·2	−28	−17	49 41	4 29	
lmouth	50 09	5 06	July 25,	1838	S	XVII	69 11·9	+3·8	69 15·7	−25	−15	49 44	4 49	$m = -68°·75$, $r = 0'·604$
lmouth	50 09	5 06	July 31,	1838	F	XI.	69 13·5	+3 8	69 17·3	−27	−16	49 42	4 51	
nd's-end	50 05	5 40	Nov. 21 & 22,	1837	R	XV	69 18·5	+2·1	69 20·6	−31	−21	49 34	4 50	
Mary's	49 55	6 17	Aug 31,	1838	F	XI.	69 26·0	+4·0	69 30·0	−47	−30	49 08	5 19	$= -67°·5$, $r = 0'·608$

DIVISION II.—INTENSITY.

The observations of the Intensity are arranged in three sections, in the same manner as those of the Dip.

SECTION I.—ENGLAND.

§ 1. *Statical Method.*

Mr. Lloyd's Observations. These were made with the needles L. 3, L. 4, (page 82), in a $4\frac{1}{2}$ inch circle, made by Robinson. Table XLII contains the detailed statement of the observations.

TABLE XLII.

[θ is the angle which the needle makes with the horizon, the southern arm being loaded with a weight. The negation sign indicates that the north pole of the needle is *above* the horizontal line.

Station.	Date.	Needle L. 3			Needle L. 4		
		Hour.	Ther	θ	Hour.	Ther	θ
	1836.	h m			h m		
Dublin ...	April 11	0 18 P.M.	57·5	− 15° 23′·1	0 43 P.M.	57·8	− 13° 26′·4
	— 15	0 30	53·	− 15 3 6	0 08	53·5	− 13 21·0
London ..	— 19	1 0	55 8	− 18 43 5	1 28	56·8	− 16 31·9
	— 21	2 58	58 5	− 18 47·6	2 37	58·5	− 16 59 9
	— 22	0 30	59·2	− 19 6·0	0 14	60·5	− 16 57 6
Shrewsbury	— 25	3 10	55·2	− 17 31·1	2 45	55·0	− 14 56·8
Holyhead .	— 27	1 20	53·	− 16 19·4	0 40	54 0	− 13 55·6
Dublin ...	May 7	1 32	57·2	− 15 52·5	1 10	56·5	− 13 22·5
	— 9	1 25	60	− 15 52 5	0 50	60·5	− 13 18 4
Dublin ...	Aug. 5	3 50	61·8	− 15 53·8	3 28	61·8	− 13 43 6
	— 6	2 35	67·8	− 16 9·2	2 10	66·5	− 13 34·4
Birkenhead	— 8	10 0 A.M.	68·9	− 18 14 9	9 0 A. M.	68·8	− 15 07·2
		10 50	66·8	− 18 07·5	10 20	67·5	− 14 58·4
Shrewsbury	— 9	11 40	67 2	− 19 4·8	11 15	65 5	− 15 56·8
		0 07 P.M.	66·5	− 19 2·5	0 20 P.M.	66 4	− 16 20·8
Hereford...	— 10	11 20 A.M.	64·5	− 19 13·5	10 50 A.M.	64·5	− 16 24 5
		0 05 P.M.	66·4	− 19 11·2	11 45	66·2	− 16 14 9
Chepstow ..	— 12	0 10	63 2	− 19 14·0	11 40	61 8	− 16 47 2
Salisbury .	— 13	11 10 A. M.	71 2	− 19 58 8	10 45	69 5	− 17 36 0
Ryde	— 15	Noon.	71·5	− 20 33·2	11 30	72·5	− 18 24·2
	— 16	0 45 P.M.	72·2	− 20 36 1	0 20 P.M.	70·0	− 18 20 8
Clifton......	— 29	11 40 A.M.	62·5	− 19 27·3	11 15 A.M.	62·5	− 16 44·2
		0 30 P.M.	63·5	− 19 21·9	0 5 P.M.	63·0	− 17 09·6
Ryde	Sept. 24	0 15	66·4	− 20 22·6	11 45 A.M.	65·8	− 22 53 5
		1 10	64·6	− 20 16·6	0 40 P.M.	65·0	− 22 45 8
Brighton. .	— 27	11 15 A.M.	61·5	− 20 41·4	11 40 A.M.	61 5	− 23 25 8
		Noon.	61 0	− 20 21·9	0 30 P.M.	61·2	− 23 11 8
London ..	Oct 4	0 45 P.M.	56 0	− 19 45·0	1 20	57·0	− 22 54·3
		1 40	57·0	− 19 42 4	2 0	56 4	− 22 32 8
Cambridge	— 8	0 20	59·5	− 19 49 0	0 40	58 5	− 22 34·8
		1 10	56 2	− 19 39 0	1 35	55·8	− 22 29·1
Lynn . .	— 10	0 55	57·8	− 19 16 5	1 25	57 5	− 21 48·6

Tabular view of the variations of the angle θ, for the purpose of ascertaining the loss of force undergone by the needles, and the period of the change. The angles are reduced to the standard temperature, 60°*.

TABLE XLIII.

Station	Date	Needle L. 3	Needle L. 4
Dublin ...	April 11 &c.	−15° 21′·2	−13° 30′·7
London . .	— 19 &c.	−18 55·0	−16 52·0
Shrewsbury	— 25	−17 38·8	15 4·8
Holyhead	— 27	−16 30·6	−14 5·2
Dublin	May 7 &c.	−15 51·7	−13 22·0
Dublin	August 5 &c.	−15 53·8	−13 32·3
Birkenhead ...	— 8	−17 58·1	−14 40·7
Shrewsbury.	— 9	−18 52·7	−15 59·2
Hereford	— 10	−19 3·6	−16 11·1
Chepstow ..	— 12	−19 8·0	−16 44·3
Salisbury . ..	— 13	−19 40·9	17 20·8
Ryde ..	— 15 &c	−20 15·7	18 4·6
Clifton .	— 29	−19 19·8	−16 52·4
Ryde	Sept. 24	−20 10·8	−22 41·0
Brighton.	— 27	−20 29·7	−23 16·6
London	Oct. 4	−19 49·2	−22 48·6
Cambridge	— 8	−19 50·1	−22 36·5
Lynn	— 10	−19 19·9	−21 52·1

Note by Mr Lloyd—It appears from this table that Needle L 3 sustained a loss of force in the interval of time which elapsed between the two observations at Shrewsbury. Now the observations at Dublin in April and May prove that the loss sustained by the needle during the series of observations in spring was comparatively trifling; while, from the results obtained at the same place in May and August, it appears that the magnetism of the needle remained perfectly steady in the interval between the two series. We are consequently conducted to the conclusion, that the change occurred in the short interval between the observations at Dublin on the 5th of August and those at Shrewsbury on the 9th; and we have every reason to believe that it was *previous* to the observation at Birkenhead, and probably due to some accident in the passage across the channel. The magnetism of the needle appears to have been steady during the remainder of the autumn series. This, we think, will appear from the difference of the angles at Shrews-

* For the mode of effecting this reduction see Fifth Report British Association, page 147

The mean of these values, 0·95469, has therefore been taken as the equivalent to unity, and the relative values of the intensity at the other stations have been computed thereby, and are inserted in the final column of the table.

Table XLV.

Station	Date	Hour	Therm	θ	δ	$\frac{\cos\theta}{\sin(\delta-\theta)}$	Intensity London =1·0000
	1837						
Little Cloisters, Westminster	June 1		58°	−17° 52′·1	69° 18′·5	95245	0·9977
	— 1		58	−17 56·6			
	July 25	9½ A M	70	−18 07·4			
	— 25	10½ A M	73	−18 00·3			
Tortington	May 17		55	−17 38	68 59·6	95390	0·9992
	— 29		56	−17 41·4			
	June 5	11½ A M	65	−17 55·6			
	— 5	½ P M	65	−17 50·2			
	July 20	4½ P M	69	−17 29·5			
	— 20	5½ P M	69	−17 37·1			
	Aug 5	2 P M	70	−17 51·2			
	— 5	2¾ P M	70	−17 49·7			
	— 31	Noon	60	−18 03·1			
	— 31	1 P M	60	−18 04·6			
	Sept 1	1½ P M	57	−17 42·1			
	— 1	2½ P M	57	−17 38·5			
Shrewsbury	— 19	3½ P M	68·5	−16 34·8	70 24·9	96009	1·0057
	— 19	4½ P M	68·5	−16 37·0			
Aberystwith	— 21	10 A M	66·5	−16 01·8	70 25·9	96430	1·0100
	— 21	10½ A M	66·5	−16 01·8			
	— 21	3½ P M	66	−15 41·5			
	— 21	4½ P M	66	−15 40·8			
Brecon	— 22	5¾ A M	54	−16 26·3	70 03·2	96041	1·0060
	— 22	6¼ A M	54	−16 30·3			
Merthyr	— 22	1½ P M	62	−16 09·8	70 04·0	96346	1·0081
	— 22	2½ P M	62	−16 13·0			
Dunraven Castle	— 25	4½ P M	59	−16 30·5	69 45·7	96215	1·0078
	— 25	5½ P M	59	−16 30·3			
	Oct 2	5 P M	62	−16 13·9			
	— 2	6 P M	62	−16 22·0			
	— 3	11 A M	65	−16 26·5			
	— 3	Noon	65	−16 25·9			
	— 5	11½ A M	65	−16 27·6			
	— 5	Noon	65	−16 26·9			
	— 5	5 P M	60	−16 31·1			
	— 5	5½ P M	60	−16 31·7			
	— 6	11½ A M	62	−16 40·6			
	— 6	Noon	62	−16 39·0			
Dover	Nov 2	½ P M	48	−18 24·7	68 52·3	94948	0·9945
	— 2	1½ P M	52	−18 29·2			
	— 3	2½ P M	50	−18 18·8			
	— 3	3 P M	50	−18 25·0			
	— 6	½ P M	50	−18 21·7			
	— 6	1½ P M	50	−18 21·4			

TABLE XLV.—(*continued*).

Station	Date	Hour	Therm	θ	δ	cos θ / sin (δ − θ)	Intensity London =1 0000
	1837						
Margate	Nov 9	11½ A M	50°	−17° 58′	69° 02′ 9	95180	0 9970
	— 9	½ P M	50	−17 56 6			
	— 10	11 A M	48	−18 01 6			
	— 10	Noon	48	−18 01 9			
London (Regent's Park)	— 14	Noon	50	−17 12 8	69 23 8	·95684	1 0022
	— 14	1 P M	50	−17 14 7			
	— 16	3 P M	37	−16 53 7			
	— 16	4 P M	37	−16 52 6			
	— 16	4½ P M	37	−17 00 6			
Tortington	Oct 15	2½ P M	56 5	−17 20 8	68 51 0	95361	0 9989
	— 15	3 P M	56 5	−17 24 2			
	— 19	11 A M	58	−17 47 3			
	— 19	12	58	−17 58 4			
	— 19	5 P M	54 5	−17 51 3			
	Nov 24	11¾ A M	60	−17 27 5			
	— 24	¾ P M	60	−17 25 2			
	1838						
	June 18	3½ P M	63	−17 46 2			
	— 18	4¼ P M	63	−17 45 7			
	— 19	8½ A M	61	−17 48 9			
	— 19	9 A M	61	−17 48 8			
	— 19	1½ P M	66	−17 39 7			
	— 19	2 P M	66	−17 37·5			
	— 23	4 P M	64	−17 53 9			
	— 23	5 P M	64	−17 49 6			
	July 9	3 P M	71	−18 12 9			
	— 9	3½ P M	71	−18 11 8			
Lew Trenchard	— 19	7½ A M	64	−17 02 5	69 19 0	95901	1 0045
	— 19	9 A M	64	−16 59 7			
	— 19	Noon	72	−16 56 8			
	— 19	2½ P.M	72	−16 52 2			
	— 20	7½ A M	58 5	−16 42 8			
	— 21	8 A M	58 5	−16 57 1			
	— 21	½ P M	65	−16 57 6			
Falmouth	— 24	4 P M	58 5	−17 36 6	69 11 9	95607	1 0015
	— 25	7½ A M	59	−17 07 5			
	— 25	8 A M	59	−17 06 6			
	— 25	1 P M	63	−17 30 8			
	— 26	4 P M	65	−17 18 8			
Dublin	— 31	1¾ P M	65	−14 29 1	70 54·6	97200	1 0182
	— 31	2¼ P M.	65	−14 29 7			
	Aug 2	2½ P M	66	−14 19 8			
	— 3	3 P M	67	−14 29 5			
	— 3	4 P M	67	−14 26 0			
Whitehaven	— 16	10½ A M	56	−14 24 8	71 10 9	97144	1·0176
	— 16	11½ A M	56	−14 19 5			
Newcastle	— 28	4½ P M	69	−15 00 8	71 09	·96870	1·0147
	— 29	7½ A M	53	−14 48			
Alnwick Castle	— 31	4½ P M	62 5	−14 39 9	71 22 6	96987	1 0159
Stonehouse	Sept 2	1½ P M	59	−14 24 9	71 19 6	97150	1 0176
	— 2	2½ P M	59	−14 22 9			
	— 4	10½ A M	60	−14 19·1			

TABLE XLV.—(*continued*).

Station	Date	Hour.	Therm	θ	δ	$\frac{\cos\theta}{\sin(\delta-\theta)}$	Intensity London =1·0000
	1838						
Helensburgh	Sept. 8	8 A.M	53·5°	−12° 54′·1	72° 17′·0	97870	1·0252
	— 9	7½ A.M	48	−12 33·6			
	— 9	8 A.M	48	−12 35·2			
	— 9	5 P.M	53	−12 43·1			
	— 9	6 P.M	53	−12 40·8			
Jordan Hill . ..	— 11	3¼ P.M	60	−12 54·0	72 14·3	97722	1·0236
	— 11	3¾ P.M.	60	−12 53·0			
	— 13	11½ A.M	61	−13 19·3			
	— 13	Noon.	61	−13 18·4			
Worcester Park	Oct. 8	11 A.M	55	−17 33·6	69 06·7	95524	1·0006
	— 8	½ P.M.	55	−17 36·1			
	— 9	11½ A.M	57	−17 19·8			
	— 9	½ P.M	57	−17 19·5			
	— 10	11½ A.M	54·5	−17 33·2			
	— 10	½ P.M	54·5	−17 31·5			
London (Kew Gardens)... ..	— 12	2¼ P.M.	48	−17 32·1	69 16·4	95479	1·0001
	— 12	3¼ P.M.	48	−17 33·9			
	— 13	10½ A.M	46·5	−17 18·8			
	— 13	11½ A.M	46·5	−17 26·8			
Tortington	— 17	11½ A.M	61	−17 45·9	68 52·4	·95375	0·9990
	— 17	½ P.M	61	−17 45·8			
	— 18	2½ P.M	54·6	−17 49·5			
	— 18	3 P.M	54·6	−17 45·8			

Omitting Dublin, which has been transferred to the Irish section, and taking a mean of the three results at Tortington for the intensity at that station, we have here twenty stations in Britain to be combined by the method of least squares: whence $x = + \cdot 000018$, $y = - \cdot 000062$; $u = - 52° 27'$, $r = \cdot 000078$; and $f = 1 \cdot 0075$, the probable value of the intensity at the mean geographical position, of which the latitude is 52° 36′, and the longitude 2° 11′.

Professor Phillips's observations.—These were made with a needle on Mr Lloyd's statical principle, employed in Mr. Phillips's six-inch circle The needle had been recently received from the maker (Robinson), when it was first used at York in June 1837; and the results obtained with it on the 3rd and 5th June, compared with those on the 15th June, indicated that its magnetism had not become steady. To obviate this inconvenience as far as might be possible, Mr. Phillips repeatedly, during the series of his determinations, brought the needle back to York, and re-examined its magnetic state. We are thus furnished with observations at that station in June, August, September, October, 1837, and in February, 1838, which are arranged in Table XLVI., and show the pro-

portion of magnetic force lost by the needle in the several intervals. It will be seen that the loss, on the daily average, progressively diminished, and, excepting in the first interval, namely, between the 4th and 15th June, was not of sufficient amount to create much uncertainty in the results, after the application of a correction assigned in the usual manner, viz. a daily rate for each interval, obtained by dividing the whole loss in an interval by the number of days which it contains. In regard to the first interval, when the loss was considerable, and where a correction applied on the above principle can scarcely be supposed an exact representation of the facts, it fortunately happens that the six included stations are all in Yorkshire, and thus, though an equable correction in this interval may make the values of the intensity at these stations appear more discrepant with each other than they otherwise would do, yet their *collective bearing* on the position and direction of the isodynamic lines is scarcely affected.

By experiments with this needle in different temperatures, Mr Phillips found 000090 the coefficient (α) of $(\tau-\tau')$ in the reduction for temperature, which has been employed in reducing the values in the column $\frac{\cos\theta}{\sin\delta-\theta}$ to a mean temperature of 60°.

Table XLVI

Observations at York, collected in one view, to show the loss of magnetism sustained by Mr. Phillips's needle. $\delta = 70° 48' 8$.

Date	Therm	θ	$\frac{\cos\theta}{\sin(\delta-\theta)}$	Interval, Days	Loss	Average daily loss
June 3 & 5, 1837	62°2	− 15° 24′ 9	0 96632			
				11	00378	00034
June 15	68 2	− 16 10 0	0 96254			
				46	·00357	00008
Aug 1	67 5	− 16 46 2	0 95897			
				38	00150	00004
Sept 7	65 0	− 17 00 0	0 95747			
				25	00082	00003
Oct 2	63 5	− 17 06 9	0 95665			
				140	00135	00001
Feb 19 & 20, 1838	35 5	− 16 55 0	0 95530			

Mr Phillips's observations at twenty-four stations in England are comprised in Table XLVII., the values of $\frac{\cos\theta}{\sin\delta-\theta}$ are re-

duced to a mean temperature of 60°: the two last columns contain the relative values of the intensity, in the first column to York, and in the second to London. The frequent repetition of the observations at York, at different dates, renders that station the proper base of Mr. Phillips's series. The observations at York and London in February and March 1838, furnish a direct comparison of the force at those stations, and by means of that comparison, a determination of its value at all the other stations relatively to the London unity.

Table XLVII.

Station.	Date	Hour.	Therm	θ	δ	$\frac{\cos\theta}{\sin(\delta-\theta)}$	Intensity York =1·0000	Intensity London =1·0000
	1837.							
Doncaster	June 3	7 A.M.	58°·0	−15° 50′·1	70° 30′·2	·96383	0·9971	1·0096
York	June 3	2½ P.M.	56·7	−15 17·3				
York	June 5	9½ A.M.	60	−15 32·3				
York	June 5	12	70	−15 25·2	70 48·8	·96632	1·0000	1·0126
York	June 15	4 P.M.	73	−16 18·7				
York	June 15	8 P.M.	63·5	−16 01·3				
Thirsk	June 6	3 P.M.	53	−14 51·3	70 50·2	·96848	1·0020	1·0155
Osmotherley	June 6	8 P.M.	42·5	−15 08·7	71 03·2	·96583	1·0002	1·0128
Hambletonend	June 7	9½ A.M.	56	−15 10·1	71 01·0	·96606	1·0008	1·0134
Whitby	June 9	7½ A.M.	52	−15 22·0	70 57·9	·96553	1·0009	1·0135
Flamborough	June 11	8 P.M.	57	−16 29·1	70 36·9	·95988	0·9958	1·0083
Scarborough	June 13	1½ P.M.	71	−16 28·3	70 41·8	·96111	0·9978	1·0103
Sheffield	June 17	6½ P.M.	70	−16 18·0	70 29·6	·96220	0·9998	1·0124
Birmingham	July 3	3 P.M.	73	−17 04·6	70 07·2	·95897	0·9980	1·0105
Birmingham	July 8	6½ P.M.	70	−16 47·1				
St. Clair's	July 19	9 A.M.	68	−18 52·7				
St. Clair's	July 22	3¼ P.M.	76	−19 0·1	69 01·2	·94786	0·9878	1·0002
St. Clair's	July 25	6¼ P.M.	66·5	−18 42·1				
York	Aug. 1	4 P.M.	67·5	−16 40·2	70 48·8	·95897	1·0000	1·0126
Calderstone	Aug. 12	12	69·5	−17 27·7	70 43·5	·95668	0·9981	1·0106
Douglas	Aug. 17	3 P.M.	68·5	−15 27·1	71 22·2	·96610	1·0081	1·0208
Castletown	Aug. 18	9 A.M.	66·2	−15 29·8	71 22·5	·96564	1·0077	1·0203
Peel Castle Inn	Aug. 18	2 P.M.	70	−15 49·0	71 24·0	·96454	1·0065	1·0192
Peel Castle Inn	Aug. 18	3½ P.M.	69	−15 39·7				
Birkenhead	Aug. 26	1½ P.M.	62	−16 33·8	70 39·4	·95980	1·0019	1·0145
York	Sept. 7	4¼ P.M.	65	−17 0·0	70 48·8	·95747	1·0000	1·0126
Coed	Sept. 20	12	68	−17 22·8	70 40·9	·95560	0·9985	1·0110
Bowness	Sept. 25	9½ A.M.	54	−15 54·7	71 18·4	·96220	1·0056	1·0182
Coniston	Sept. 27	8½ A.M.	51·5	−15 39·4	71 19·5	·96346	1·0070	1·0196
Patterdale	Sept. 27	1¾ P.M.	52	−15 55·5	71 19·6	·96202	1·0054	1·0181
Penrith	Sept. 28	10¼ A.M.	50	−15 51·0	71 23·4	·96222	1·0057	1·0184
Carlisle	Sept. 29	10¾ A.M.	56·5	−15 42·1	71 28·5	·96357	1·0072	1·0198
Newcastle	Sept. 30	7¼ A.M.	53	−16 06·9	71 18·1	·96120	1·0047	1·0178
York	Oct. 2	10 A.M.	63	−17 10·4	70 48·8	·95665	1·0000	1·0126
York	Oct. 2	4 P.M.	64	−17 3·5				
	1838							
London	Mar. 28	4½ P.M.	58	−19 22·2	69 19·6	·94346	0·9876	1·0000
York	Feb. 19	9 A.M.	33	−16 54·8	70 48·8	·95530	1·0000	1·0126
York	Feb. 20	4½ P.M.	38	−16 55·2				

If we combine the mean results at the twenty-four stations in this table by the method of least squares, we obtain the following values $x = +\cdot000061$, $y = -\cdot000066$, $u = -47^\circ\ 37'$, $r = \cdot000090$, and $f = 1\cdot0136$, at the mean geographical position in lat. 53° 49′, and long. 2° 08′.

Mr. Fox's observations.—These were made with a 4½ inch needle, on the principle described by its maker, Mr T. B. Jordan, of Falmouth, in the third volume of the "Annals of Electricity," &c. The needle has a small grooved wheel on its axle, which receives a thread of unspun silk, furnished with hooks, to which weights may be attached The weights employed were successively 2·0 grains, 2·1 grains, 2·2 grains, and with each weight the intensities are in the inverse ratio of the angle of deflection produced, corrections being applied for differences of temperature at the different stations. The following table exhibits the angles of deflection occasioned by the respective weights, and the values of the intensity deduced therefrom The angles are reduced to a common temperature, 1° of the centigrade scale having been found by experiment to be equivalent to 2′, or 2′·4 in the angle.

TABLE XLVIII

Station	Date	Weight	Angle of Deflection	Intensity	Mean	Place of Observation
	1838	Grains	° ′			
London	May 22 June 4 & 8	2·0 2·1 2·2	48 36·7 51 55·3 55 33·0	1·0000 1·0000 1·0000	1·0000	Mean of results in a field N of Maiden Lane, in the Regent's Park, and at Westbourne Green
Eastbourne	June 20	2·0 2·1 2·2	48 57 52 19 55 57	0·9938 0·9921 0·9952	0·9937	In the grounds of Davies Gilbert, Esq
Eastwick Park	June 16	2·0 2·1 2·2	48 35 51 57 55 40	0·9997 0·9996 0·9986	0·9993	In the grounds
Combe House	July 2	2·0 2·1 2·2	48 25 51 45 55 18	1·0023 1·0024 1·0031	1·0026	In the grounds
Falmouth	July 5 & 7	2·0 2·1 2·2	48 29 51 48 55 20	1·0013 1·0017 1·0026	1·0018	In Mr Fox's grounds

§ 2. *By the Method of Vibrations.*

The observations by this method include twenty-seven stations, i. e. 18 by Captain Ross; 7 by Major Sabine; and 2 by Mr. Lloyd.

1st. Captain Ross's determinations were made with a cylinder (X) vibrated in an apparatus on the well-known plan of M. Hansteen. The loss of magnetism sustained by the cylinder during the time of its employment, from July 1837 to June 1838, was very considerable, and was occasionally so irregular as to prevent any satisfactory conclusion whatsoever being drawn from the observations. On a careful examination, there appeared two intervals, viz. from the middle of September to the middle of November 1837,—and from April 24 to June 5, 1838,—during which there was reason to infer that the loss of magnetism, though considerable, had been tolerably uniform and regular. During the second interval, viz. from April 24 to June 5, 1838, on both which days the cylinder was vibrated in London, the increase in the time of vibration at the *same* station affords a *direct* measure of the diminution in its magnetic intensity; and being divided by the number of days comprised in the interval, furnishes the amount of the daily correction. But in the first interval we have the additional disadvantages of having no *direct* observation showing the amount of the loss of magnetism, and no *direct* comparison with the force in London: and it is necessary, consequently, to have recourse to indirect means for the purpose of determining these particulars. On the 19th of September, 1837, Captain Ross vibrated cylinder X at Birkenhead; and on the 21st of September, at Douglas, in the Isle of Man. In Table XLVII. we have the value of the intensity at both these stations relatively to the London unity, determined by Mr. Phillips; and in Table XLIV. we have Mr. Lloyd's determination of the force at Birkenhead. We may employ these determinations to supply the time of vibration in London corresponding to the observations with the cylinder at Douglas and Birkenhead. In like manner we may accomplish a second indirect comparison with London by means of Captain Ross's observations at Falmouth on the 18th of November, 1837, combined with the values of the intensity at that station determined by Mr. Fox, (Table XLVIII.), and Major Sabine, (Table XLV.). The several observations and processes by which the times of vibration of the cylinder in London have been derived at different epochs, are comprised in Table XLIX.; and in its final column is

shown the average daily loss of magnetism experienced in each of the two intervals; which is subsequently applied in Table L., in assigning the corresponding times of vibration in London, on days when the cylinder was employed elsewhere.

Table XLIX.

Station.	Date	Time of vibration at 60°.	Observed dip	Intensity of London = 1·0000	Corresponding times of vibration of Cylinder X in London		Daily loss of force in the respective intervals
	1837.						
Birkenhead...	Sept. 19	275·22	70° 35′·0	1·0145 Phillips 1·0112 Lloyd	268·45	268·37	s 0·06
Douglas	Sept. 22	279·27	71 20·3	1·0208 Phillips	268·30		
Falmouth....	Nov 18	271·48	69 16·1	1·0015 Sabine 1·0018 Fox	............271·70		
	1838						
London......	April 21	275·84	69 15·0	1·0000..	.... 275·84		0·015
London	June 2&5	280·06	69 15·0	1·0000..............	............280·06		

Table L. contains the observations made by Captain Ross with cylinder X, and the values of the intensity derived from them. The coefficient in the formula for the reduction to a mean temperature, is ·00017: the reduction has been applied in the column entitled "corrected time."

Table L.

Station.	Date.	Hour	Temp.	Time of 100 vibrations	Corrected Time	Observed Dip.	Corresponding time of vibration in London.	Intensity. London = 1·0000.
	1837.	h m		s	s	° ′	s	
Birkenhead..	Sept. 19	1 48 P.M.	70°	275·81	275·22	70 35·0	268·45	1·0128
		2 17	70	275·58				
Douglas, (Isle of Man).	Sept. 22	9 47 A.M.	60	279·2	279·27	71 20·3	268·30	1·0208
		10 36	60	279·35				
Pwllheli	Oct. 14	5 11 P.M.	47	274·62	275·71	70 32·5	269·81	1·0178
	— 15	8 55 A.M.	47	275·30				
		10 57	60	275·98				
Dolbro'	— 18	10 50	58	270·53	270·68	69 25·4	270·00	1·0018
		11 14	60	270·75				
ton.	— 22	2 30 P.M.	56	271·4	271·66	69 34·0	270·24	1·0061
		2 55	56	271·57				
Pembroke.....	— 26	1 17	56	272·75	272·95	69 55·9	270·48	1·0128
		1 48	56	272·80				

TABLE L. (*continued.*)

Station	Date	Hour	Temp.	Time of 100 vibrations.	Corrected Time.	Observed Dip	Corresponding time of vibration in London	Inten Lond =1 0
	1837.	h m	°	s	s	° ′	s	
Swansea	Oct. 27	5 1 P.M.	45	273·38				
	— 28	11 46 A.M.	51	273·12	273·66	69 46·7	270·60	1·00
	— 29	6 59	54	273·23				
Ilfracombe..	Nov 3	5 2 P.M.	46	271·42	272·06	69 36·9	270·80	1·00
Padstow ..	— 14	1 12	56	270·85	271·10	69 25·1	271·19	1·00
		1 35	56	271·00				
Falmouth.....	— 18	3 42	50	271·02	271·48	69 16·1	271·70	1·00
Land's End ..	— 23	11 6 A.M.	56	270·98	271·14	69 18·5	272·00	1·00
		11 29	56	270·93				
	1838							
London..... ..	April 24	3 41 P.M.	53	275·52	275·84	69 15·0	275·84	1·00
			53	275·51				
York	— 28	1 40	48	284·43	285·16	70 45·2	276·24	1·00
		2 7	50	284·85				
Scarbro'	May 1	10 56 A.M.	47	285·7				
		11 28	48	286·43	286·85	70 43·0	276·54	0·99
		11 49	49	286·68				
Bridlington...	— 2	3 44 P.M.	60	285·82				
		5 50	56	285·0	285·46	70 38·8	276·66	1·00
		6 35	51	285·08				
Wadworth ..	— 10	3 39	60	284·07	284·07	70 27·5	277·50	1·01
Nottingham..	— 12	7 46 A.M.	58	283·02	283·12	70 16·3	277·70	1·01
Louth	— 16	11 40	57	283·7	283·81	70 19·5	278·10	1·01
		1 7 P.M.	58	283·67				
Cromer	— 21	0 7	60	281·05	281·21	69 46·1	278·65	1·00
	— 22	0 6 P.	60	281·38				
Lowestoffe...	— 23	11 31 A.M.	61	279·90				
		0 16 P.M.	62	279·73				
	— 24	10 14 A.M.	61	280·30				
		10 58	64	280·68	280·66	69 20·2	278·90	0·99
		1 51 P.M.	60	280·65				
	— 25	10 28 A.M.	52	281·0				
		0 37 P.M.	53	281·10				
		1 12	54	281·17				
Harwich	— 29	11 46 A.M.	63	280·13				
		1 40 P.M.	66	279·93				
	— 30	10 23 A.M.	65	280·20	280·00	69 15·4	279·50	0·99
		0 3 P.M.	66	280·43				
		11 14 A.M.	66	280·53				
London.......	June 2	11 52	65	280·27				
		0 21 P.M.	65	280·32				
	— 5	10 58 A.M.	65	280·25	280·06	69 15·0	280·06	1·000
		0 5 P.M.	68	280·53				

2 Mr Lloyd's observations were made with two cylinders, L (*a*) and L (*b*), vibrated in Hansteen's apparatus. The agreement of their times of vibration in Dublin, in April and May 1836, is an evidence that their magnetic state remained unaltered in the interval The values of the intensity at Shrewsbury and Holyhead are deduced, in relation to the London unity, by means of the force in Dublin, which, in a subsequent part of this Report, will be shown to be 1 0195 The coefficient in the formula of reduction to a mean temperature, is 00025 for both cylinders. (5th Report, B A., pp. 119 and 120.)

Table LI.

Station	Date	Cyl	Temp	Time of 100 vibrations	Corrected Time		Observed Dip	Intensity London = 1 0000	
	1836		°	s	s		° ′		
Dublin	April 11	L (*a*)	56 2	243 56	243 76	243 78	71 03 5	1 0195	1 0195
	— 12		61 0	243 96	243 88				
	— 15		56 5	243 50	243 69				
	April 11	L (*b*)	56 5	292 93	293 16	293 33		1 0195	
	— 12		59 2	293 50	293 53				
	— 15		56 8	293 09	293 29				
Shrewsbury	April 25	L (*a*)	62 0	241 64	241 51	241 53	70 27 6	1 0095	1 0080
			62 0	241 68	241 55				
	— 25	L (*b*)	70 0	291 58		290 83		1 0066	
Holyhead	April 27	L (*a*)	54 2	244 08	214 42	244 42	71 08 5	1 0192	1 0195
			53 2	244 02	244 42				
	— 27	L (*b*)	59 0	293 87		293 92		1 0198	
Dublin	May 7	L (*a*)	57 6	243 96	244 10	243 96	71 03 5	1 0195	1 0195
	— 9		61 0	243 90	243 83				
	May 7	L (*b*)	58 0	292 95	293 08	293 21		1 0195	
	— 9		61 0	293 43	293 34				

3 Major Sabine's observations were made with Mr Lloyd's cylinders L (*a*) and L (*b*), and with a pair, in all respects similar, designated as L (3) and L (4). The results are comprised in the two following Tables, LII. and LIII. Table LII. contains observations made to determine the value of the intensity at Toitington, in Sussex, and Table LIII the values at six other stations in Great Britain in Table LIII the value of the force in Dublin = 1 0195, has supplied the means of checking the magnetism of the cylinders.

Table LII.

Deduction of the Intensity at Tortington.

1. By comparison with Dublin. The observations at Dublin are by Professor Lloyd, those at Tortington by Major Sabine The intensity at Dublin = 1 0195 The co-efficient in the formula for the reduction to a mean temperature of L (3) = 00027, of L (4) = 00022

Cyl	Station	Date.		Hour	Therm	Time of 100 Vibrations	Corrected Time	Dip	Inten Lond = 1·0
		1838.		h m	°	s	s	° ′	
L (3).	Tortington . .	Feb.	9	4 40 P.M	42	295 67	297 05	68 55 1	
		—	10	1 31	36	295 09			
	Dublin	March	3	1 37	46 2	307 79	308 81	70 58 4	0 9
		—	3	2 02	47	308 00			
		—	5	3 03	46 5	307 35			
	Tortington . .	March	10	1 44	46	296 74	297 75	68 55 1	
		—	10	2 38	45 5	296 53			
L (4).	Tortington ...	Feb.	9	5 09 P M	41	271 22	272 28	68 55 1	
		—	10	0 34	36	270 78			
	Dublin	March	3	2 46	46 8	282 58	283 40	70 58 4	0 9
		—	3	3 08	44 2	282 58			
		—	5	2 40	47 2	282 57			
	Tortington ...	March	10	10 43 A M	49	272 53	272 99	68 55 1	
		—	10		46	271 98			

2. By direct comparison with London. The London observations were made in the Palace Gardens at Kew

Cyl.	Station	Date		Hour	Therm	Time of 100 Vibrations		Dip	Inten Lon = 1
		1838		h m					
L (a).	London..	Oct	13	3 0	39	237 77	238 98	69 16 4	0
		—	13	3 16	40	237 81			
	Tortington ..	Oct	18	0 08	52	236 65	237 16	69 53 5	
		—	18	0 27	53	236 80			
L (b).	London	Oct.	13	11 45	44	303 92	305 21	69 16 4	0
		—	13	0 15	44	304 06			
	Tortington ..	Oct	17	1 28	58 5	303 26	303 20	68 53 5	
		—	18	10 17	48 0	302 18			
		—	18	11 07	50 5	302 46			

The values of the intensity at Tortington, relatively to unity in London thus deduced, are as follows :

L (3), 0 9963, L (a), 0 9986,
L (4), 0 9985, L (b), 0 9965,
Mean, 0 9975

Table LIII.

Deduction of the Intensity at Six Stations in Britain.

I. (h)

Station	Date.		Hour.	Therm.	Time of 100 Vibrations	Corrected Time.	Observed Dip.	Corresponding Time of Vibration in London	Intensity, London = 1·0000.
	1838.		h m	°	s	s	° ′	s	
don	June	1	10 21 A.M.	62	284·17	284·01	69 17·4	284·01	1·0000
	—	1	11 04	62	284·17				
nouth . ..	July	7	1 10 P.M.	67	283·73*	283·40	69 12·0	283·94	0·9997
	–	25	0 18 P.M.	62	283·66				
olin	Aug.	6	3 42	67	292·88	292·32	70 54·6	283·87	1·0195
	—	8	1 42	63	292·48				
tehaven...	Aug.	16	4 25	57·5	294·46	294·64	71 10·7	283·94	1·0180
vcastle ...	Aug.	28	2 28	71·5	295·22	294·38	71 09·0	283·94	1·0183

I. (a).

Station	Date.		Hour.	Therm.	Time of 100 Vibrations	Corrected Time.	Observed Dip.	Corresponding Time of Vibration in London	Intensity, London = 1·0000.
olin	Aug.	6	4 12 P.M.	66	246·30	245·77	70 54·6	238·60	1·0195
	—	8	3 44	65	245·81				
tehaven...	Aug.	16	4 55	57	247·81	248·00	71 10·7	238·80	1·0169
vcastle ...	Aug.	28	2 57	73·5	248·40	247·72	71 09·0	238·80	1·0177
	—	30	1 00	63·0	248·07†				
ehouse ...	Sept	3	11 30	59	248·86	248·92	71 19·6	238·80	1·0171
nsburgh .	Sept.	9	2 50	55	253·22	253·58	72 17	238·80	1·0310
	—	9	3 20	57	253·45				
an Hill ..	Sept.	13	3 24	59	253·66	253·72	72 14	238·80	1·0273
don	Oct.	18	3 00	59	237·77	238·08	69 16·4	238·08	1·0000
	—	18	3 16	60	237·81				

The results in Table LIII., collected in one view, are as follows:

Station.	Intensity, London = 1·0000.			Station.	Intensity, London = 1·0000
	I. (h).	I. (a).	Mean.		I. (a).
Whitehaven.........	1·0180	1·0169	1·0175	Helensburgh........	1·0310
Newcastle	1·0183	1·0177	1·0180	Jordan Hill........	1·0273
Falmouth	0·9997	....	0·9997	Stonehouse	1·0171

If we combine, by the method of least squares, the results at the twenty-seven stations at which the intensity was thus de-

* Observed by Mr. Fox. † Observed by Captain Ross.

termined by horizontal vibrations,—namely, eighteen stations by Captain Ross, exclusive of those which have served to examine the magnetism of the cylinder; two stations by Mr. Lloyd; and seven by Major Sabine,—we obtain the following values: $x = + \cdot 000064$, $y = - \cdot 000069$; $u = - 47° 14'$; $r = \cdot 000094$. The mean geographical position is 52° 43′ N., and 2° 18′ W.

If we now collect in one view the several values of u and r which have been obtained from the intensity observations in England, we have as follows:

TABLE LIV.

Observer.	Method.	No. of Stations.	Mean Geographical Position		Values of	
			Lat.	Long.	u	r
Lloyd	Statical	12	52° 01′	1° 56′	−54° 49′	·000082
Phillips	Statical	24	53 49	2 08	−47 37	·000080
Sabine	Statical .. .	20	52 30	2 11	−52 27	·000078
Ross, Sabine, Lloyd	Horizontal vibrations	27	52 43	2 18	−47 14	·000094

If we regarded the several values of u and r in Table LIV., as entitled to weight proportioned to the number of stations of which each is the representative, we should assign a preponderance to the values obtained by the horizontal vibrations, which the circumstances of the observations from which they are derived would scarcely justify. To give them exactly their just weight, would require a lengthened investigation of the respective probable errors, not only of the two methods, but of the horizontal method under some disadvantages, as shown in page 143. The occasion would not justify the expenditure of the necessary time and labour; and I have assigned the arbitrary value of 18 to the horizontal deductions from the twenty-seven stations; making, in this particular instance, three horizontal determinations equivalent to two statical. Thus weighted, we obtain −50° 48′ and ·000086 as the mean values of u and r derived from the English series, corresponding to the central geographical position in 52° 48′ N. lat., and 2° 07 W. long.

Section II.—Scotland.

§ 1 *Observations by the Statical Method.*

Major Sabine's Observations—These were made in the summer of 1836, with the statical needle S (2), an account of them is contained in the report on the Scotch Magnetical Lines, in the 6th vol of the Reports of the British Association. Between the 30th of July and the 4th of October, in which interval the magnetism of the needle was shown to have sustained no change, twenty-two stations were observed at, including two in Ireland, viz Bangor and Dublin. These are now transferred to the Irish Series, and being thus included in their more appropriate place, will be omitted here. At the time of the publication of the Scotch report, no *direct* comparison had been made of the intensity in Scotland with that in London, but its values at the several Scottish stations relatively to London were given provisionally, by means of the observations in Dublin, and by adopting 1 0208 as the ratio of the force in Dublin to unity in London, according to a determination of Mr. Lloyd's, published in the Transactions of the Royal Irish Academy, in 1836 The values at the Scottish stations were consequently subject to be altered by any modification which Mr. Lloyd's determination in Dublin might subsequently receive. In the present report Mr Lloyd has given a corrected value for the force in Dublin, resulting from a much larger number of determinations. The corrected value is 1 0195. With this value, therefore, and the comparative observations at Dublin and Helensburgh, published in the Sixth Report of the British Association, we may now derive a more correct expression, relatively to London for the intensity at Helensburgh as the base of the Scottish determinations

The observations contained in the Scotch report presented a double comparison between Dublin and Helensburgh one by the observations of the 22nd July, in Dublin, and the 27th July, at Helensburgh, the other by those of August 2, and September 13 and 14, at Helensburgh, and October 4, at Dublin. They are presented in the following table

Note—Between the first and second comparisons the needle sustained an accident, which is related in the Scottish Report, and which accounts for the angles of deflection being different in the two comparisons

TABLE LV

Station.	Date	Ther	θ	δ	$\frac{\cos\theta}{\sin(\delta-\theta)}$	Intensity. Dublin = 1	London =
	1836.						
Dublin	July 22	56°	−18° 27′·2	71° 03′·6	·94843	1 0000	1 0195
Helensburgh . .	July 27	60	−17 17 9	72 16 8	·95178	1 0067	1 0263
Helensburgh ...	Aug. 2	65	−18 59 7	72 16 8 }	·94572	1 0062	1·0258
Helensburgh .	Sept. 13 & 14	64	−19 06 1	72 16 8 }			
Dublin	Oct 4	49	−19 53 3	71 03 2	·93993	1·0000	1·0195

Whence it results that $\left(\frac{1{\cdot}0263 + 1{\cdot}0258}{2}\right) = 1{\cdot}0261$ expresses the force at Helensburgh relatively to unity in London, as derived through the medium of Dublin.

In 1838 I visited Helensburgh for the purpose of obtaining a *direct* comparison with London. The observations which I then made are included with the series already given in Table XLV; their result is 1·0252. The near agreement of this result, with that obtained in 1836 through the medium of Dublin, is satisfactory, both in confirming the relation of the Scottish intensities to London, and in showing the confidence to which this mode of experiment is entitled. I have taken 1·0258 as the force at Helensburgh, considering the determination through Dublin as entitled to rather the most weight; and have computed from it the value of the intensity at the other stations, as inserted in the final column of Table LVI.

TABLE LVI.

Station.	Date.	Ther.	θ	δ	$\frac{\cos\theta}{\sin(\delta-\theta)}$ Temp 60°	Intensity. Helensburgh = 1·0000	London = 1 0000.
	1836						
Helensburgh {	Aug. 2	65°	−18° 59′·7	} 72° 16′·8	·94572	1·0000	1·0258
	Sept. 13 & 14	64	−19 06 1				
Cumbray	July 30	64	−18 31 9	72 01·2	·94839	1·0028	1 0287
Tobermorie .	Aug 10	70	−15 29 3	73 07·7	·96452	1·0199	1·0462
Loch Slapin .	— 14	56	−15 59	73 02 2	·96130	1·0165	1·0427
Glencoe..... .	— 17	57	−17 50·8	72 17 2	·95173	1·0064	1·0324
Inverness ... {	— 20	59	−16 44·2	} 72 46·5	·95718	1 0121	1·0382
	— 24	58	−16 53·7				
Golspie	— 23	51	−17 08·4	72 55 6	·95510	1·0099	1·0360
Gordon Castle	— 25	60	−16 52 4	72 40·9	95693	1·0119	1 0380
Alford . .	— 27	57	−18 22	72 22	94900	1·0035	1·0290
Braemar..	— 30	44	−18 40·1	72 14 2	94668	1·0010	1·0269
Blairgowrie .	— 31	59	−18 06·1	71 54 7	·95052	1·0051	1·0310
Newport.. . . .	Sept. 1	60	−18 40·8	72 17 5	·94745	1 0018	1 0277
Kirkaldy	— 3	60	−18 37·7	72 11	·94769	1·0021	1·0279
Melrose	— 6	51	−19 43 7	71 37	·94111	0 9951	1·0208
Dryburgh	— 7	56	−19 56 1	71 33·7	·94023	0·9942	1·0199
Edinburgh . .	— 8	55	−19 24	71 49 4	·94320	0·9973	1·0231
Glasgow... .. .	— 9	56	−19 24	72 01·7	·94330	0·9974	1 0232
Loch Ranza .	— 16	57	−18 55·9	72 23·0	·94600	1 0003	1 0261
Cambleton	— 16	53	−18 16 1	71 56	94925	1 0037	1·0296
Loch Ryan ..	— 18	52	−19 31·8	71 43 5	94230	0 9964	1·0221

In the discussion of these observations in the 6th Report of the British Association, I have adverted to the frequent influence of the igneous rocks in Scotland in producing what may be termed *station error* In the table in page 20 of that Report, the intensities observed at Tobermorie, both by the statical and horizontal methods, are shown to have been affected, apparently by an error of this nature, to a degree much exceeding that of the results at any other station. In combining the results of both methods, therefore, for the values of x, y, &c , I have thought it right to omit altogether the intensities at Tobermorie We have, therefore, the statical results at nineteen stations to combine by the method of least squares, whence we obtain the following values $x = + \cdot 000083$, $y = - \cdot 000107$, $u = - 52° 15'$, $r = \cdot 000136$ The mean geographical position is in latitude 56° 22′ N. and longitude 4° 01′ W.

Captain Ross's Observations —These were made with two needles, R L (3) and R L (4), on Professor Lloyd's principle, used in Captain Ross's six-inch circle One of these needles (R L 3) appears to possess the peculiar property of preserving its magnetism unchanged in different temperatures, requiring no reduction to a mean temperature Table LVII contains a series of experiments with it, made by Captain Ross, by which it will be seen that in differences of temperature, including the whole range of natural temperatures to which it is likely to be exposed, the time of vibration of the needle remained unaltered.

Table LVII.

Observations to investigate the influence of differences of temperature on the time of vibration of Captain Ross's statical needle R L (3).

Date	Hour	Ther	Time of 100 Horizontal Vibrations	Date	Hour	Ther	Time of 100 Horizontal Vibrations
1839	h m	°	s	1839	h m	°	s
Jan 17	10 39 A M	32	428 4	Jan 17	2 29 P M	60	428 0
	10 54	32	428 4		2 45	56	428 2
	11 42	98	428 8		3 01	53	428 2
	11 58	92	428 4		3 16	51	428 0
	0 17 P M	83	428 2		3 32	50	428 4
	0 56	92	428 4	Jan 18	10 32 A M	28	428 4
	1 11	87	428 4		10 47	29	427 8
	1 27	81	428 8		11 08	30	428 4
	1 44	75	428 6		11 34	30	428 4
	1 58	70	428 2		11 49	30	428 6
	2 14	64	428 4		0 05 P M	30	428 5

The following table, No LVIII contains two series of experiments of a similar nature, with R L (4), one made by Major

Sabine, and the other by Captain Ross, the results according extremely well in the value of the coefficient deduced.

TABLE LVIII.

Observations to ascertain the coefficient in the formula for reduction to a mean temperature of Captain Ross's statical needle R I. (4).

Major Sabine, Tortington, December 18, 1838.

Hour	Temp	Time of 100 Vibrations.	Means	
h m	°	s		
10 38 A.M.	47	480·4	480·4 at 46·75	Here, in the formula, $a = \frac{2(T-T')}{T'(\tau-\tau')}$,
11 31	46 5	480·4		$T = 480·25$; $T - T' = 0·75$,
1 57 P.M.	100	480 8	481·0 at 103·3	$\tau - \tau' = 55·8$; whence $a =$ ·000056.
2 22	103	481·4		
2 42	98	480·8		
5 02	49	479·4	480·1 at 48·3	
6 43	48	480·8		
7 44	48	480·0		

Captain Ross, London, February 21, 1839

Hour.	Temp.	Time of 100 Vibrations.	Means.	
h m	°	s		
1 14 P.M.	38	474·2	474 22 at 38°	
1 45	38	474·23		
2 19	104	474·96	474 90 at 102·5	Here $T = 474·2$; $T - T' = 1·16$
2 41	103	474·93		$\tau - \tau' = 45°·1$; whence, $a =$ ·000054.
3 7	103	474·61		
3 30	100	475·01		
3 51	88	474·36	474·51 at 75·7	
4 31	77	474·72		
4 53	71	474 66		
5 15	67	474 30		
8 7	50	473·98	474 03 at 50	
8 32	50	474·08		

By the mean of the two determinations $a =$ ·000055 ; which being multiplied by ·43429, the modulus of the common system of logarithms = ·000024, the coefficient of $(\tau-\tau')$ in the correction for temperature.

In the following table are collected the observations made with these needles in London, in July 1838, and in December of the same year, for the double purpose of examining the steadiness of their magnetism in the interval,—during which they had been employed in the observations in Scotland now under notice, and in a similar series in Ireland,—and of determining the angle of deflection in London as the base station of both series.

Table LIX.

Needle	Date.	Hour.	Ther	θ	δ	$\frac{\cos\theta}{\sin(\delta-\theta)}$	Intensity
	1838.	h m					
R L (3).	July 7	5 30 P.M.	70°	−28° 38′·4			
	July 12	0 30	70	−27 1·9	69 14·2	·89683	0·9986
	——	1 30	70	−27 48·3			
							1·0000
	Dec. 5	3 0	45	−26 32·9			
	——	3 40	45	−26 30·3	69 14·7	·89932	1·0014
						Mean. ·89807	
R L (4).	July 10	5 0	68	−13 33·2			
	July 12	4 0	72	−13 32·7	69 14·2	·98061	1·0005
	——	5 0	72	−13 30·7			
							1·0000
	Dec. 4	3 0	47	−13 28·8			
	——	4 30	47	−13 28·0	69 14·7	·97970	0·9995
						Mean. ·98015	

On comparing the observations with both needles in July and in December, we may conclude that the magnetism of both had remained unchanged during the interval; the small differences are only such as frequently occur on different days; they are, moreover, in different directions, and so far will compensate each other in the final deduction.

In Table LX. are comprised Captain Ross's observations with these needles at nine stations in Scotland and the north of England.

TABLE LX. Needle, R. L. (3).

Station.	Date.	Hour	Ther	θ	δ	cos θ / sin (δ − θ)	Intensity London = 1·0000.
	1838.	h m				Therm. cor.	
Aberdeen ...	July 10	3 0 P.M.	63	− 23° 32′·3	72° 27′·6	·92185	1·0266
Lerwick	— 25	3 0 P.M.	54	− 22 20·1	73 44·9	·92947	1·0351
	— 26	0 30	53	− 22 33·1			
		1 10	53	− 22 21·8			
Kirkwall......	Aug. 1	11 30 A.M.	60	− 22 4·3	73 20·4	·93081	1·0366
		0 30 P.M.	60	− 22 5·5			
Inverness ..	— 14	2 30 P.M.	59	− 21 49·6	72 46·2	·93118	1·0370
		3 15	59	− 21 53·1			
Newcastle ...	— 29	4 0 P.M.	60	− 24 55·9	71 13·0	·91202	1·0156
		5 0	60	− 24 57·1			

Needle, R. L (4).

Station.	Date.	Hour	Ther	θ	δ	cos θ / sin (δ − θ)	Intensity London = 1·0000.
Aberdeen ...	July 10	4 0 P.M.	63	− 7 35·2	72 27·6	1·0056	1·0270
Lerwick	— 25	3 30 P.M.	54	− 4 52·2	73 44·9	1·0159	1·0365
	— 26	2 0	55	− 4 51·0			
		3 0	55	− 5 0·0			
Kirkwall......	Aug. 1	1 30 P.M.	61	− 4 55·6	73 20·4	1·0175	1·0381
		2 10	61	− 5 0·			
Inverness ...	— 14	3 30 P.M.	60	− 5 14·7	72 46·2	1 0180	1·0386
		4 30	60	− 5 11·1			
Newcastle ...	— 29	3 00 P.M.	61	− 9 51·9	71 13·0	·99727	1·0175
		3 30	61	− 9 52·9			
Stonehouse...	Sept. 8	10 40 A.M.	61	− 9 48·5	71 24·1	·99713	1·0173
		Noon.	63	− 9 50·7			
Jordan Hill.	— 11	2 0 P.M.	61	− 7 36·7	72 20·0	1·0055	1·0259
		3 0	62	− 7 41·5			
	— 13	10 0 A.M.	63	− 8 2·8			
		11 0	63	− 8 3·5			
Berwick	— 17	11 30 A.M.	60	− 8 19·9	71 41·9	1·0050	1·0254
		Noon.	60	− 8 12·0			
Dunkeld......	— 20	0 15 P.M.	57	− 7 37·2	72 23·1	1·0063	1·0267
		2 0	57	− 7 37 4			

Collecting the results in one view, we have as follows:

TABLE LXI.

Station.	R. L. (3.)	R. L. (4)	Mean	Station	R. L. (3).
Aberdeen ...	1·0266	1·0270	1·0268	Dunkeld......	1·0267
Lerwick......	1·0351	1·0365	1·0358	Jordan Hill..	1·0259
Kirkwall ..	1·0366	1·0381	1·0373	Berwick......	1·0254
Inverness ...	1·0370	1·0386	1·0378	Stonehouse...	1·0173
Newcastle	1·0156	1·0175	1·0165		

If we combine the results at these nine stations by the method of least squares, we obtain the following values: $x = +\ 000080$; $y = -\ {\cdot}000069$; $u = -\ 40^\circ\ 38'$; $r = {\cdot}000106$. The mean geographical position is in latitude 56° 52′ and longitude 2° 45′ W.

§ 2. *By the Method of Vibrations.*

Major Sabine's Observations.—These observations were made in the summer of 1836; a detailed account of them is given in the Sixth Report of the British Association. Two cylinders, L *a* and L *b*, were vibrated at twenty-two stations in Scotland, between the 28th July and 18th September, during which interval the magnetism of the cylinders was proved to have been steady. The times of vibration at the several stations, reduced to a temperature of 60°, are inserted in Table LXII., being taken from the Sixth Report of the Association. The values of the horizontal intensity are given in the table in relation to unity at Helensburgh; and those of the total force to unity in London: the intensity at Helensburgh having been already shown to be as 1·0258 to 1·0000 in London.

Table LXII.

Station	Date	Needle	Time of Vibration, Therm 60	Horizontal Intensity Helensburgh 1·0000		Observed Dip.	Total Intensity London = 1·0000.
	1836.						
Helensburgh	July 28– Aug. 2	L. a	251·05	1·0000	1·0000	72 16·8	1·0258
	Sept. 13-14	L. a	251·27				
	July 28—Aug 2	L. b	302·08	1·0000			
	Sept. 13-14......	L. b	301·33				
Great Cumbray	July 30	L. a	249·82	1·0108	1·0087	72 01·2	1·0203
	—	L. b	300·71	1·0066			
Loch Gilphead..	Aug. 7...........	L. a	249·75	1·0113	1·0100	72 07·7	1·0279
	—	L. b	300·22	1·0089			
Tobermorie	Aug. 10	L. a	254·34	0·9755	0·9753	73 07·7	1·0492
	—	L. b	305·46	0·9752			
Loch Slapin	Aug. 14	L. a	254·50	0·9740	0·9761	73 02·2	1·0446
	—	L. b	305·04	0·9782			
Artornish.........	Aug. 16	L. a	252·57	0·9866	0·9878	72 42·9	1·0380
	—	L. b	303·75	0·9889			
Glencoe	Aug. 17	L. a	250·82	1·0035	1·0051	72 17·2	1·0315
	—	L. b	301·17	1·0067			
Fort Augustus...	Aug. 19	L. a	253·34	0·9829	0·9839	72 10·4	1·0315
	—	L. b	304·00	0·9849			
Inverness......	Aug. 21	L. a	253·11	0·9831	0·9850	72 40·5	1·0385
	Aug. 24	L. a	253·53				
	Aug. 21	L. b	303·16	0·9869			
	Aug. 24	L. b	304·25				
Golspie	Aug. 23	L. a	254·48	0·9741	0·9735	72 55·6	1·0353
	—	L. b	305·87	0·9729			
Gordon Castle...	Aug. 25	L. a	252·72	0·9877	0·9886	72 40·9	1·0371
	—	L. b	303·29	0·9895			
Rhynie	Aug. 26	L. a	251·09	1·0006	1·0018	72 25·7	1·0358
	—	L. b	301·24	1·0031			
Alford	Aug. 28–29....	L. a	252·23	0·9916	0·9926	72 22·0	1·0231
	— 28	L. b	302·67	0·9936			
Braemer	Aug. 30	L. a	250·96	1·0016	1·0035	72 14·2	1·0270
	—	L. b	300·88	1·0055			
Blairgowrie.....	Aug. 31	L. a	248·10	1·0249	1·0260	71 54·8	1·0319
	—	L. b	297·69	1·0272			
Newport	Sept. 1...........	L. a	251·26	0·9992	0·9995	72 17·5	1·0300
	—	L. b	301·72	0·9998			
Kirkaldy...	Sept. 3	L. a	250·79	1·0030	1·0042	72 11·0	1·0247
	—	L. b	300·87	1·0055			
Melrose	Sept. 6	L. a	247·56	1·0293	1·0311	71 37	1·0208
	— 6 and 7 ..	L. b	296·85	1·0330			
Dryburgh	Sept. 7...........	L. a	247·20	1·0323		71 33·7	1·0191
Loch Ranza......	Sept. 16	L. a	252·57	0·9889	0·9897	72 23	1·0210
	—	L. b	303·15	0·9905			
Campbelton......	Sept. 17	L. a	249·33	1·0148	1·0163	71 56·0	1·0232
	—	L. b	299·05	1·0178			
Loch Ryan......	Sept. 18	L. a	247·68	1·0283	1·0299	71 43·4	1·0254
	—	L. b	297·06	1·0315			

Omitting Tobermorie, for the reasons assigned in page 157, and combining the results at the other twenty-one stations by the method of least squares, we obtain the following values: $x = +\cdot000080$; $y = -\cdot000118$; $u = -55^\circ\ 46'$; $r = \cdot000143$. The mean geographical position is latitude $56^\circ\ 35'$, and longitude $4^\circ\ 15'$ W.

Captain Ross's Observations.—These were made in the summer of 1838 with a cylinder (X) described in page 148. It was vibrated at Westbourne Green, near London, in June and July 1838, and again in December of the same year, having been used in the interval both in Scotland and in Ireland. The observations at Westbourne Green, showing that its magnetism underwent no change in this interval, are contained in the following table.

Table LXIII.

Date.	Hour.	Therm.	Time of 100 Vibrations.	Mean Time of 100 Vibrations at 60°.		Observed Dip.
1838.	h m		s			
June 2...	11 52 A.M.	65°	280·27			
— ...	0 21 P.M.	65	280·32			
June 5..	10 59 A.M.	65	280·25			
—	0 4 P.M.	68	280·53	279·99		
June 8...	11 49 A.M.	67	279·78			
—	0 12 P.M.	67	279·63			
July 6..	11 05 A.M.	68	280·38			
—	11 27 A.M.	70	280·40		280·06	69° 14′·5
July 12...	10 50 A.M.	68	280·83	280·24		
—	11 12 A.M.	68	280·98			
Nov. 30 ..	11 0 A.M.	50	279·48			
—	11 27 A.M.	51	279·52	279·95		

The coefficient in the formula for the reduction to a mean temperature is ·00017.

Table LXIV. contains the observations with cylinder (X) at ten stations in Scotland, and at two stations in the north of England, viz. Newcastle and Stonehouse. The values of the total intensity in the final column, relatively to unity in London, have been computed by means of the time of vibration of this cylinder in London shown in the preceding table.

Table LXIV.

Station	Date		Hour	Therm	Time of 100 Vibrations	Corrected Time	Observed Dip	Intensity London = 1 0000.
	1838		h m	°	s	s	° ′	
Aberdeen .	July	18	2 10 P M	64	299 57	299 37	72 27 6	1 0292
			3 1	61	299 42			
Lerwick .	July	23	2 52 P M	50	307 82			
		24	11 12 A M	54	309 35			
		26	11 0	52	308 82	309 27	73 44 9	1 0386
		27	11 12	60	309 90			
		28	0 40 P M	54	308 98			
Kirkwall	July	31	11 50 A M	56	304 92			
	Aug	1	10 50	59	305 12			
		3	11 44	58	305 12	305 31	73 20 4	1 0403
		4	11 21	60	305 82			
		6	11 28	57	305 08			
Wick	Aug	8	11 12 A M	58	305 32	305 43	73 19 9	1 0390
Golspie	Aug	10	11 42 A M	66	303 28			
		11	11 27	63	303 48	303 26	73 04 4	1 0382
		12	10 28	62	303 58			
Inverness	Aug	13	1 32 P M	58	300 38	300 51	72 46 0	1 0395
		14	Noon	59	300 48			
Newcastle	Aug	29	8 3 A M	52	290 9			
		30	10 40	59	291 28	291 41	71 13 0	1 0167
			11 15	60	291 6			
Stonehouse	Sept	1	0 46 P M	57	292 87	292 86	71 24 0	1 0163
		3	11 11 A M	60	292 70			
Culgruff	Sept	6	0 45 P M	58	293 0			
		7	10 18 A M	47	293 05	293 50	71 35 7	1 0219
		8	0 43 P M	52	293 35			
		9	9 47 A M	51	293 00			
Jordan Hill.	Sept	11	5 27 P M	60	298 18			
		12	11 0 A M	56	298 22	298 39	72 20 3	1 0289
		13	8 54	60	298 55			
Berwick ..	Sept	17	9 4 A M	56	293 83	294 02	71 41 9	1 0241
		18	9 2	52	293 62			
Dunkeld .	Sept	20	10 22 A M	58	298 82	298 92	72 23 1	1 0281
		21	10 19	48	298 32			

If we combine these twelve results by the method of least squares, we obtain the following values, viz. $x = +\,000091$, $y = -\cdot000086$, $u = -43^\circ\ 32'$, $r = 000125$ The mean geographical position is 56° 56′ N. lat., and 2° 58′ W. long.

If we collect in one view the values of u and r which have been obtained from the several series in Scotland, we have as as follows

TABLE LXV

Observer	Method.	No of Stations	Mean Geographical Position		Values of	
			Lat	Long	u	r
Sabine	Statical	19	56° 22′	4° 01′	−52° 15′	000136
Ross	Statical	9	56 52	2 45	−40 38	000106
Sabine	Hor Vibrations	21	56 35	4 15	−55 46	000143
Ross	Hor Vibrations ..	12	56 56	2 58	−43 32	000125

Regarding the values of u and r as entitled to weight proportioned to the number of stations of which each is the representative, and giving equal weight to a result by each method, we obtain −50° 02′ and 000132 as the mean values of u and r derived from the Scottish series, and corresponding to the central geographical position in 56° 40′ N. lat., and 3° 30′ W longitude.

SECTION III.—IRELAND.

(*By the* REV H LLOYD.)

1. *Method of Vibration.*

The body of results obtained by this method in Ireland has received some valuable accessions, and undergone other important alterations, since the publication of the Irish Magnetic Report We shall consider these under the following heads. 1 Additional observations; 2. Corrections of the results previously obtained, 3 New determinations of the intensity at the base stations.

Additional Observations —These consist in a comparison of the intensity at London and Dublin, made by myself in the year 1836, a comparison of Dublin and Bangor, made by Major Sabine in the latter part of the same year; a comparison of London and Dublin, by the same observer, in the year 1838; and a complete series of observations made by Captain James

Ross, in the year 1838, at twelve distinct stations throughout the island. This latter series, forming in themselves a complete body of results, will be considered separately. The additional observations made by Major Sabine and myself are contained in the following table*.

Table LXVI.

Cylinder L (*a*).

Station.	Date.	Hour	Time.	Temp.	Corr. Time.
		h m	s	° ′	s
Dublin	April 11, 1836.	11 14	243·56	58·2	243·76
	— 12	11 8	243·96	61·0	243·88
	— 15	11 14	243·50	56·5	243·69
	Mean.		243·67	57·9	243·78
London	April 19	12 11	236·02	59·5	236·04
	— 21	2 3	235·94	60·0	235·93
	— 22	11 51	236·23	61·5	236·13
	Mean.		236·06	60·3	236·02
Dublin	May 7	12 30	234·96	57·6	244·10
	— 9	12 6	243·90	61·0	243·83
	Mean.		243·93	59·3	243·96
Dublin . .	July 21, 1836.	0 0	243·47	59·0	243·58
	— 25	7 30	243·11	55·0	243·41
	Mean.		243·29	57·0	243·47
Bangor	Sept. 21	9 45	246·53	48·6	247·20
	— 21	10 15	246·72	49·0	247·39
	Mean.		246·62	48·8	247·30
Dublin	Oct. 3	10 10	243·25	45·0	244·16
	— 3	2 8	243·22	47·0	244·01
	— 3	2 30	243·09	48·0	243·82
	— 4	1 45	243·18	51·5	243·70
	Mean.		243·18	47·9	243·92
London	June 1, 1838.	11 37	236·27	62·0	236·15
	— 1	11 56	236·15	62·0	236·03
	Mean.		236·21	62·0	236·09
Dublin	Aug. 6	4 12	246·30	66·0	245·93
	— 8	3 44	245·81	63·0	245·63
	Mean.		246·05	64·5	245·78
London	Oct. 13	3 0	237·77	39·0	239·01
	— 13	3 16	237·81	40·0	238·99
	Mean.		237·79	39·5	239·00

* The details of the comparison of Bangor and Dublin have been already printed in the Scotch Magnetic Report: they are reprinted here, so that all the results obtained in Ireland may be seen in connexion.

Table LXVII

Cylinder L (*b*)

Station	Date	Hour		Time	Temp	Corr Time
	1836	h	m	s	°	s
Dublin	April 11	10	48	292·93	56 5	293 16
	— 12	10	44	293 50	59 2	293 53
	— 15	10	48	293 09	56 8	293 29
	Mean			293 17	57 5	293 33
London	April 19	11	36	284 17	61 0	284 08
	— 21	1	38	284 44	60 5	284 38
	— 22	11	22	284 27	60 5	284 21
	Mean			284 29	60 7	284 22
Dublin	May 7	12	5	292 95	58 0	293 08
	— 9	11	40	293 43	61 0	293 34
	Mean			293 19	59 5	293 21
Dublin	July 24	8	30	293 22	59 0	293 29
	— 25	8	0	292 25	54 0	292 69
	— 25	8	40	292 57	55 5	292 90
	Mean			292 68	56 2	292 96
Bangor	Sept 21	11	10	295 28	49 6	296 04
Dublin	Oct 3	9	25	291 02	44 5	292 15
	— 3	9	45	291 24	44 5	292 37
	— 3	2	55	291 37	49 6	292 13
	— 4	1	15	291 73	53 5	292 20
	Mean			291 34	48 0	292 21
London	June1,1838	10	21	284 17	62 0	284 00
	— —	11	4	284 17	62 0	284 00
	Mean			284 17	62 0	284 00
Dublin	Aug 6	3	42	292 88	67 0	292 37
	— 8	1	42	292 48	63 0	292 26
	Mean			292 68	65 0	292 31

Correction of the Results.—The first correction that seems to be required is in the series of results obtained in the North of Ireland, in the autumn of the year 1834 On a comparison of the times of vibration of cylinder L (*b*) in Dublin, at the commencement and end of that series, it will be seen that the magnet sustained a loss of force; and an attentive examination of the other parts of the series shows that this loss occurred *immediately* previous to the final observation in Dublin. This fact will be seen very evidently by means of the following table, which contains the corrected rates of the *two* cylinders, and the deduced values of the intensity compared with the intensity in Dublin *at the time of the initial observation.* The results obtained with the two cylinders present a very close agreement, except in the final observation.

TABLE LXVIII.

Station	L (*a*).		L (*b*).	
	Time.	Intensity.	Time.	Intensity.
	s		s	
Dublin	243·90	1·000	292·74	1·000
Armagh	246·88	·976	296·40	·975
Carn	248·10	·966	297·71	·967
Strabane	248·51	·963	298·22	·964
Enniskillen	248·42	·964	297·83	·966
Dublin	243·92	1·000	293·62	·994

Hence, instead of comparing the other results of cylinder L (*b*) with the *mean* of the initial and final observations in Dublin, they are to be compared with the *initial* observations *alone*; the final observations not being comparative with the rest of the series. The loss of force sustained by the cylinder L (*b*) being ·006, the amount of the correction is

$$\delta h = -\cdot 003 \times h;$$

h denoting the horizontal intensity, as originally deduced, and δh its correction.

A correction of a similar kind (that is, depending on the rate of vibration at the base station) seems to be required also in the series of results obtained in the west and south of Ireland in the summer of 1835. In reducing the observations of this series, I had taken as the Dublin time, the mean of the initial and final times, without regarding the number of separate observations; but, if we suppose the difference between these times to be owing to errors of observation, or to any *fluctuating* source, it is manifest that we should take, as the Dublin time, the mean of the separate results themselves. This seems to be the proper course in the present instance. The initial time is the result of a single observation only, and that taken under the disadvantage of an unusually high temperature; so that the difference between it and the final time (which difference is nearly the same for the two cylinders) is probably due either to the irregular fluctuations of the horizontal intensity, or to error in the coefficient of the temperature correction.

It is easy to determine the amount of the required correction. If T denote the time of vibration at any station, T′ that at the base station, and h the ratio of the horizontal intensities,

$$h = \frac{T'^2}{T^2}.$$

Hence if $\delta T'$ denote the small correction in the value of T′, and δh the corresponding correction of h,

$$\frac{\delta h}{h} = \frac{2\,\delta T'}{T'}.$$

To apply this in the present instance, we have

	L (a)	L (b)
	s	s
Mean of separate observations	243 43	293·18
Mean of initial and final results . .	243 29	293 06
Correction of T′, or $\delta T'$.	+0 14	+0 12
Resulting value of $\frac{\delta h}{h}$ . . .	+ 0011	+ 0008

The corrections here obtained are applied to all the results of the series (Aug 19, to Sept 15, 1835) in Table LXVIII

Values of the Intensity at the Base stations —The following is a summary of the comparisons of the horizontal intensity in London, Dublin, and Limerick, as contained in Table LXIX.

Horizontal intensity in Dublin, referred to London .

July, August, 1835	Cyl	R c	Int	=	9456
— — —	—	R d	—	=	9421
Sept Oct Nov. 1835	—	L a	—	=	9354
— — — —	—	L b	—	=	9348
April, May, 1836	—	L a	—	=	·9367
— — —	—	L b	—	=	9392
June, Aug Oct. 1838	—	L a	—	=	9340
— — — —	—	L b	—	=	9440
Mean				=	9390

Horizontal intensity in Limerick, referred to London

July, Aug Sept. 1834	Cyl	S b	Int	=	9396
July, 1835	—	S b	—	=	·9470
July, August, 1835.	—	R c	—	=	9461
July, August, 1835.	—	R d	—	=	·9513
Mean				=	·9460

Horizontal intensity in Limerick, referred to Dublin:

October,	1834	Cyl.	L *a*	Int.	= 1 0075
—	—	—	L *b*	—	= 1 0015
July, Aug	1835	—	R *c*	—	= 1 0005
— —	—	—	R *d*	—	= 1·0098
Aug Sept	1835	—	L *a*	—	= 1 0039
— —	—	—	L *b*	—	= 1 0055
Nov. Dec	1835	—	L *a*	—	= 1 0001
— —	—	—	L *b*	—	= 1·0021
		Mean			. = 1 0039

Now, the comparison of Dublin with London and with Limerick being each the mean of eight separate comparisons, while that of Limerick and London is deduced from four only, we have (see Fifth Report, p 133)

$$A = 2\,B = C.$$

Hence the formulæ of page 134 become

$$\delta x = \frac{\frac{1}{2}\,b\,(c_{\prime} - c)}{\frac{1}{2}\,(a^2 + c_{\prime}^2) + 1}, \quad \delta y = -\frac{a\,(c_{\prime} - c)}{\frac{1}{2}\,(a^2 + c^2) + 1};$$

but

$$a = 9390, \quad b = 9460, \quad c = 1{\cdot}0039,$$

$$c_{\prime} = \frac{b}{a} = 1{\cdot}0075, \quad c_{\prime} - c = 0036$$

and, substituting these values,

$$\delta x = +{\cdot}0009, \qquad \delta y = -{\cdot}0017,$$

$$x = a + \delta x = 9399;$$

$$y = b + \delta y = {\cdot}9443.$$

The numbers in the 6th column of the following table are deduced from those of the 5th, by multiplying by one or other of these numbers, according as the station has been compared, in the first instance, with Dublin or with Limerick

It will readily appear, from the principles laid down in pages 95 *et seq*, that the *weights* of these determinations are expressed by the formulæ

$$X = A + \frac{B\,C\,c^2}{B\,a^2 + C}, \quad Y = B + \frac{A\,C}{A\,a^2 + C\,c^2},$$

Now, A=C=8, B=4; substituting these values, and those of *a*, *b*, *c*, given above, we have

$$X=10{\cdot}8, \quad Y=8{\cdot}2,$$

the weight of a single comparison being unity.

Table LXIX.

Intensity of the Horizontal Force

Station	Date.	Cyl	No	Hor Int	Hor Int (London=1)
	1834				
Limerick	July, Sept	S *b*	5		·9396
London	Aug 20–27	S *b*	20		1 0000
Limerick	Sept Oct	S *b*	3	1 0000	
	— 9, Oct 8	L *a*	2	1 0000	9443
	— 9, — 8	L *b*	3	1 0000	
Ballybunian	— 16	S *b*	1	1 0010	
	— 17	L *a*	1	9954	9441
	— 17	L *b*	1	1 0029	
Glengariff	— 27	S *b*	1	1 0110	
	— 27	L *a*	1	1 0110	9511
	— 27	L *b*	1	9997	
Killarney	Oct 4	S *b*	1	1 0039	
	— 4	L *a*	1	1 0086	9503
	— 4	L *b*	1	1 0066	
Kiltanon	— 12	S *b*	1	9983	9427
Templemore	— 17	S *b*	1	1 0404	9824
Clonmel	— 19	S *b*	1	1 0092	9530
Fermoy	Dec 2	S *b*	1	1 0157	·9591
Limerick	— 10	S *b*	1	1 0000	·9443
Dublin	Oct 10–28	L *a*	6	1 0000	9399
	— 11	L *b*	2	1 0000	
Limerick	— 8	L *a*	1	1 0075	·9441
	— 8	L *b*	2	1 0015	
Carlingford	— 13	L *b*	1	·9868	·9275
Armagh	— 14, 15	L *a*	2	9761	9172
	— 14, 15	L *b*	2	9754	
Coleraine	— 18, 20	L *b*	2	9870	9277
Carn	— 21	L *a*	1	9665	9086
	— 21	L *b*	1	9669	
Strabane	— 23	L *a*	1	9633	9056
	— 23	L *b*	1	9636	
Enniskillen	— 24	L *a*	1	·9640	9070
	— 24	L *b*	1	·9661	

Station	Date	Cyl	No	Hor Int	Hor Int London=1
	1835				
London	July 4–7	S *b*	12		1 0000
	July 8–20	R *c*	25		1 0000
	Aug 28–31	R *d*	14		1 0000
Limerick	July 27, 28	S *b*	2		9470
	— 27–29	R *c*	10	1 0005	9461
	— 29–31	R *d*	11	1 0098	9513
Dublin	Aug 16	R *c*	3	1 0000	9456
	— 14	R *d*	3	1 0000	9421
Markree	— 19	R *c*	3	9531	9012
	— 19, 20	R *d*	3	9558	9005
Dublin	Aug 19	L *a*	5	1 0000	9399
	Sept 12–15	L *b*	4	1 0000	
Markree	Aug 21	L *a*	1	9580	8998
	— 21	L *b*	2	9566	
Ballina	— 22	L *a*	1	9545	8959
	— 22	L *b*	1	9517	
Belmullet	— 24	L *a*	1	9497	8906
	— 24	L *b*	2	9454	
Achill	— 25	L *a*	1	9576	8990
	— 25	L *b*	1	9552	
Leenan	— 26	L *a*	1	9621	9051
	— 26	L *b*	1	9636	
Oughterard	— 27	L *a*	1	9777	9191
	— 27	L *b*	1	9781	
Ennis	— 28	L *a*	1	9995	9386
	— 28	L *b*	1	9977	
Limerick	— 29	L *a*	1	1 0039	9443
	— 29	L *b*	1	1 0055	
Cork	— 31	L *a*	1	1 0211	9597
	— 31	L *b*	1	1 0294*	
Waterford	Sept 1	L *a*	1	1·0125	9512
	— 1	L *b*	1	1 0115	
Broadway	— 2	L *a*	2	1 0215	9615
	— 2	L *b*	1	1 0246	
Rathdrum	— 3	L *a*	1	1 0013	9422
	— 3	L *b*	1	1 0035	
London	Sept 19–22	L *a*	6		1 0000
	Oct 23, 24	L *b*	7		1 0000
Dublin	Sept 12–15	L *a*	7		9354
	Nov 5, 6	L *b*	6		9348
Dublin	Nov Dec Jan	L *a*	8	1 0000	
	Nov Dec Jan	L *b*	7	1 0000	
Limerick	Dec 19–23	L *a*	3	1 0001	
	— 19–23	L *b*	3	1 0021	
London	Apr 19–22	L *a*	3		1 0000
	1836	L *b*	3		1 0000
Dublin	Apr 11–15	L *a*	5		9367
	May 7–9	L *b*	5		9392

* Disturbing influence suspected in this observation the result has been accordingly omitted in deducing the number in the last column

Station	Date	Cyl	No	Hor Int	Hor Int (London=1)
	1836				
Dublin	July 24, 25	L a	6	1 0000	9399
	Oct 3, 4	L b	7	1 0000	
Bangor	Sept 21	L a	2	9710	9154
	— 21	L b	1	9768	
London	June 1, Oct 13, 1838	L a	4		1 0000
	— 1	L b	2		1 0000
Dublin	Aug 6–8	L a	2		9340
	— 6–8	L b	2		9440

The following table contains the resulting values of the horizontal intensity, those of the total intensity thence deduced, and the latitudes and longitudes of the stations The values of the dip employed, in deducing the total from the horizontal intensities, will be found in Table XXXVI.

TABLE LXX

Station	Lat	Long	Hor Int	Total Int
	° ′	° ′		
Dublin	53 21	6 16	9399	1 0203
Limerick	52 40	8 35	9443	1 0260
Ballybunian	52 30	9 41	9441	
Glengariff	51 45	9 31	9511	1 0283
Killarney	52 3	9 31	9503	1 0300
Kiltanon	52 52	8 43	9427	1 0318
Templemore	52 47	7 48	9824	
Clonmel	52 20	7 41	9530	
Fermoy	52 7	8 16	9591	1 0259
Carlingford	54 2	6 11	9275	1 0279
Armagh	54 21	6 39	9172	1 0272
Coleraın	55 8	6 40	·9277	1 0250
Carn	55 15	7 15	9086	1·0346
Strabane	54 49	7 28	9056	1 0303
Enniskillen	54 21	7 38	9070	1 0321
Markree	54 12	8 26	·8998	1 0316
Ballina	54 7	9 7	·8959	1 0313
Belmullet	54 13	9 57	8906	1·0274
Achill	53 56	9 52	8990	1·0308
Leenan	53 36	9 40	·9051	
Oughterard	53 26	9 18	9191	
Ennis	52 51	8 58	9386	1 0270
Cork	51 54	8 26	9597	1 0236
Waterford	52 16	7 8	9512	1 0209
Broadway	52 13	6 24	9615	1 0194
Rathdrum	52 55	6 14	9422	1 0137
Bangor	54 39	5 42	9154	1·0266

Of these results, those obtained at Templemore, Carlingford, and Coleraın, are not included in the computation of the lines,

being manifestly affected by disturbing action. The disturbance at the two latter stations is obviously due to the presence of trap rocks

In deducing the lines of total intensity, I have been guided by the principles laid down in page 95 and *seq*, and have accordingly assigned *double* weight to the results in Dublin and Limerick, the weight of each of the other comparisons being taken as unity. The results of the computation are as follows

$$L = 1{\cdot}0268, \quad M = +{\cdot}0000748, \quad N = +{\cdot}0000501,$$
$$u = -33^\circ\ 48', \quad r = {\cdot}0000900;$$

L denoting the intensity at the central station (Lat. $=53^\circ\ 21'$, Long. $=8^\circ\ 0'$), the intensity at London being unity, M and N the increase of the intensity, corresponding to each geographical mile of distance in the direction of the two coordinates, u the angle which the isodynamic line, passing through the central station, makes with the meridian, and r the increase of the intensity in the direction perpendicular to that line

The lines of *horizontal intensity* rest upon a somewhat broader basis, there being four stations where the horizontal force was observed without the dip In deducing them, I have given a weight of *two* to the results obtained at Dublin, Limerick, and Markree, the weight of each of the other determinations being unity We find, accordingly,

$$L = {\cdot}9290, \quad M = -{\cdot}000190, \quad N = -{\cdot}000368;$$
$$u = -62^\circ\ 40', \quad r = {\cdot}000414$$

Captain Ross's observations are contained in the following table They were made in the autumn of the year 1838, with a single cylinder, designated as R (X) in the following pages. The stations are twelve in number, and are distributed uniformly over the island The permanency of the magnetism of the cylinder during this series, and its time of vibration at Westbourn Green, near London, have been already shown in Table LXIII.

Table LXXI

Station	Date	Hour	Therm	Time of 100 Vibrations	Mean reduced to Temperature 60
	1838	h m	°	s	s
Waterford	Oct. 3	42 3 P M.	56	287 18	287 45
	— 4	10 17 A M	56	287 35	
Cork . .	— 6	5 32 P M	54	285 43	286 20
	— 7	11 40 A M.	63	286 47	
	— 8	0 38 P M	54	286 08	
Valencia Island	— 12	11 26 A M	54	286 83	287 07
	— 13	10 26 A M	53	286 68	
Killarney	— 17	11 2 A M	52	286 75	287 17
		11 40 A M	52	286 96	
	— 18	2 3 A M	52	286 65	
	— 19	10 22 A M	58	286 87	
Limerick	— 22	11 8 A M	60	288 33	288 33
		Noon	62	288 47	
	— 23	8 41 A M	54	287 98	
		11 6 A M	57	288 18	
Shannon Harbour	— 26	9 35 A M	50	290 35	290 88
		10 14 A M	52	290 52	
Dublin	— 29	11 28 A M	50	288 82	289 12
		11 51 A M	50	288·78	
	— 30	7 59 A M	40	287 95	
		8 30 A M	41	288 13	
Armagh	Nov 1	4 32 P M	42	292	292 95
	2	8 44 A M	43	292 17	
Londonderry	— 5	11 41 A M	52	295 18	295 55
	— 6	11 13 A M	51	295 07	
Markree	— 10	11 17 A M	44	294 33	295 16
	— 11	4 13 P.M	43	294 33	
Westport	— 13	0 32 P M	45	293 97	294 66
	— 14	11 15 A M	42	293 70	
Edgeworth's Town	— 19	0 15 P M	45	291 00	292·04
	— 20	10 59 A M	44	291 28	

The following table contains the resulting values of the horizontal intensity; those of the total intensity thence deduced, and the latitudes and longitudes of the stations. The dips employed in deducing the total from the horizontal intensities, are given in Table XXXIX; the London dip used in the computation is the mean dip at Westbourn Green (Table III), reduced to the mean epoch of the present series.

Table LXXII.

Station	Lat.	Long.	Hor Int	Total Int
Waterford	52° 16′	7° 8′	·9493	1·0205
Cork	51 54	8 26	·9576	1·0239
Valencia	51 56	10 17	·9517	1·0285
Killarney	52 3	9 31	·9511	1·0271
Limerick	52 40	8 35	·9435	1·0262
Shannon Harbour	53 14	7 52	·9270	1·0287
Dublin	53 21	6 16	·9383	1·0205
Armagh	54 21	6 39	·9140	1·0296
Londonderry	55 0	7 20	·8979	1·0314
Markree	54 12	8 26	·9003	1·0321
Westport	53 48	9 29	·9034	1·0345
Edgeworth's Town	53 42	7 33	·9196	1·0264

In deducing the values of L, M, N, equal weights have been assigned to all the results. The following are the values obtained for the lines of total intensity.

$$L = 1{\cdot}0276, \quad M = +{\cdot}0000858, \quad N = -{\cdot}0000671\,;$$
$$u = -38^\circ\ 0', \quad r = {\cdot}000109.$$

For the lines of *horizontal* intensity, we find

$$L = {\cdot}9269, \quad M = -{\cdot}000138, \quad N = -{\cdot}000379\,;$$
$$u = -70^\circ\ 0', \quad r = {\cdot}000403.$$

2. *Statical Method.*

Additional Observations.—The observations made according to the statical method since the printing of the Irish Magnetic Report, consist of my own observations in London and Dublin, in the year 1836; Major Sabine's observations in Limerick, Dublin, and Bangor, in the autumn of the same year; a comparison of London and Dublin, by the same observer, in the year 1838; and a series of observations, at eight distinct stations, made by Captain James Ross, towards the close of the latter year. The details of my own observations, and of those of Major Sabine, are given in the following tables. Captain Ross's observations, as before, will be considered separately.

Table LXXIII.

Mr. Lloyd's Observations, Needles L 3 and L 4.

Needle	Station.	Date.	Hour. h	m	Temp. °	Angle. °	′
Needle L 3.	Dublin	April 11, 1836	12	18	57·5	−15	23·4
		— 15	12	30	53·0	−15	3·6
		Mean.	12	24	55·2	−15	13·5
	London ..	April 19	1	0	55·8	−18	43·5
		— 21	2	58	58·5	−18	47·6
		— 22	12	30	59·2	−19	6·0
		Mean.	1	29	57·8	−18	52·4
	Dublin	May 7	1	32	57·2	−15	52·5
		— 9	1	25	60·0	−15	52·5
		Mean	1	28	58·6	−15	52·5
		Aug 5	3	50	61·8	−15	53·8
		— 6	2	35	67·8	−16	9·2
		Mean.	3	12	64·8	−16	1·5
Needle L 4.	Dublin ...	April 11, 1836.	12	48	57·8	−13	26·4
		— 15	12	8	53·5	−13	21·0
		Mean	12	25	55·6	−13	23·7
	London .. .	April 19	1	28	56·8	−16	31·9
		— 21	2	37	58·5	−16	59·9
		— 22	12	14	60·5	−16	57·6
		Mean.	1	26	58·6	−16	49·8
	Dublin	May 7	1	10	56·5	−13	22·5
		— 9	12	50	60·5	−13	18·4
		Mean.	1	0	58·5	−13	20·5
		Aug. 5	3	28	61·8	−13	48·6
		— 6	2	10	66·5	−13	34·4
		Mean.	2	49	64·2	−13	[illegible]

TABLE LXXIV.

Major Sabine's Observations, Needle S 2.

Station	Date	Temp	Angle.
		°	° ′
Limerick	July 15, 1836	58·0	−17 32·8
	— 15	57·0	−17 25·9
	— 16	59·8	−17 21·5
	Mean.	58·3	−17 26·7
Dublin	July 22	54·0	−18 31·6
	— 22	56·0	−18 28·1
	— 23	57·5	−18 22·7
	Mean.	55·8	−18 27·5
Bangor	Sept. 21	50·0	−18 55·9
Dublin	Oct. 4	49·0	−19 53·3
London	June 1, 1837.	58·0	−17 52·1
	— 1	58·0	−17 56·6
	July 25	70·0	−18 7·4
	— 25	73·0	−18 0·5
	Mean.	64·8	−17 59·2
	Nov. 14	50·0	−17 12·8
	— 14	50·0	−17 14·7
	— 16	*37·0	−16 58·7
	— 16	37·0	−16 52·6
	— 16	37·0	−17 0·6
	Mean.	42·2	17 2·9
Dublin	July 31, 1838	65·0	−14 29·1
	— 31	65·0	−14 29·7
	Aug. 2	66·0	−14 19·8
	— 3	67·0	−14 29·5
	— 3	67·0	−14 26·0
	Mean.	66·0	−14 26·8
London	Oct. 12, 1838.	48·0	−17 32·1
	— 12	48·0	−17 33·9
	— 13	46·5	−17 18·3
	— 13	46·5	−17 26·8
	Mean.	47·2	−17 27·8

Correction of the Results.—The only correction which seems necessary in the results already recorded is that due to the effect of temperature upon the needle S 2, the temperature-correction of that needle having been obtained by Major Sabine subsequently to the publication of the Irish Magnetic Report. This correction is small, the coefficient in the logarithmic formula being only ·000024*. The corrected results are given in Table LXXV.

As the expression of the intensity deduced by the statical method is a function of the dip, as well as of the inclination of the needle when loaded, it may be necessary to show that the changes in the dip-corrections of the needles (page 104 and *seq.*)

* Sixth Report, p. 108

can have no sensible effect upon the deduced values of the intensity

The ratio of the intensity at any station to that at the base-station being denoted by ϕ, we have (Fifth Report, p 147,)

$$\phi = \frac{\cos\theta \sin(\delta_{,} - \theta_{,})}{\cos\theta_{,} \sin(\delta - \theta)}$$

Hence, supposing δ and $\delta_{,}$ to vary by any small and equal amount, $\Delta\delta$, the corresponding variation of ϕ will be expressed by the formula

$$\frac{\Delta\phi}{\phi} = \{\cot\text{an}(\delta_{,} - \theta_{,}) - \cot\text{an}(\delta - \theta)\}\,\Delta\delta.$$

Now the quantity, $\Delta\delta$, is very small, and (where the stations are not widely separate) the coefficient by which it is multiplied is likewise small; for such stations, then, the resulting value of $\frac{\Delta\phi}{\phi}$ is inconsiderable On substituting the numerical values of δ, $\delta_{,}$, θ, $\theta_{,}$, for the extreme stations of the present series, it will be seen that the correction does not affect the fourth place of decimals

Values of the Intensity at the Base stations.—The following is a summary of the comparisons of the intensity at London, Dublin, and Limerick, as contained in Table LXXV

Intensity at Dublin, referred to London

Aug Sept. 1834	Needle L 4	Int	= 1 0194
Sept Oct Nov 1835	— L 4	—	= 1 0212
April, May, 1836 .	— L 3	—	= 1 0194
April, May, 1836 .	— L 4	—	= 1·0189
June 1837, Oct. 1838	— S 2	—	= 1 0183
	Mean . .		= 1·0194

Intensity at Limerick, referred to London

June, July, Aug 1834	Needle L 4	Int	= 1 0262

Intensity at Limerick, referred to Dublin

Aug. Sept 1835 . .	— L 4	Int	= 1·0030
July 1836 . .	— S 2	—	= 1·0062
	Mean . .		= 1·0046

We have therefore (Fifth Report, p 148),

$$a = 1\,0194, \quad b = 1\,0262, \quad c = 1\,0046;$$

$$c_{,} = \frac{b}{a} = 1\,0067, \qquad c_{,} - c = \,0021,$$

$$A = 5, \qquad B = 1, \qquad C = 2.$$

Substituting these values in the formulæ of page 134 (Fifth Report), we find

$$\delta x = + \cdot 0003, \qquad \delta y = - \cdot 0012 ;$$
$$x = a + \delta x = 1 \cdot 0197 ;$$
$$y = b + \delta y = 1 \cdot 0250.$$

The results in the 6th column of the following table are deduced from those of the 5th, by multiplying by one or other of these numbers, according as the station has been originally compared with Dublin or with Limerick.

The *weights* due to the preceding determinations are given by the formulæ of page 170. Substituting the numerical values of A, B, C, &c., we find

$$X = 5 \cdot 7, \qquad Y = 2 \cdot 4 ;$$

the weight of a single comparison being unity. Adopting the nearest whole numbers, we may consider the deduced value of the intensity in Dublin as equivalent to the result of *six* separate comparisons; and that of the intensity in Limerick as equivalent to *two*.

Table LXXV.

Intensity of the Total Force.

Station	Date	Needle.	No	Intensity	Intensity. (London = 1.)
London	August, 1834.	L. 4	3		1·0000
Limerick	June, July.	—	3		1·0262
Dublin	Sept. 22—29.	—	4		1·0194
Dublin	Sept. Oct.	L. 4	5	1·0000	1·0197
*Carlingford	Oct 13	—	1	1·0166	1·0366
Armagh...........	— 14, 15.	—	2	1·0044	1·0242
*Colerain	— 20.	—	1	·9997	1·0194
Carn	— 21.	—	1	1·0151	1·0351
Strabane	— 23.	—	1	1·0100	1·0299
Dublin	Aug. Sept. 1835.	L. 4	5	1·0000	1·0197
Markree............	Aug. 21.	—	1	1·0091	1·0290
Ballina	— 22.	—	1	1·0077	1·0276
Belmullet	— 24.	—	1	1·0093	1·0292
Achill	— 25.	—	1	1·0096	1·0295
Galway	— 28.	—	1	1·0086	1·0285
Ennis	— 28.	—	1	1·0055	1·0253
Limerick	— 29.	—	1	1·0030	1·0229
Cork	— 31.	—	1	·9992	1·0189
Waterford	Sept. 1.	—	1	·9966	1·0162
Broadway	— 2.	—	1	·9976	1·0173
Gorey...	— 3.	—	1	·9933	1·0129
Rathdrum	— 3.	—	1	·9944	1·0140
London	Sept. Oct. 1835.	L. 4	6		1·0000
Dublin	Sept. Nov.	—	7		1·0212

* Evident local disturbance at these two stations. The district about Carlingford is intersected with trap dykes; Colerain lies within the basaltic field

Station.	Date	Needle	No	Intensity	Intensity (London=1)
Limerick	July, Dec 1835	S 2	5	1 0000	1 0250
Ballybunian	Nov 8	—	1	1 0083	1 0335
Valencia	— 12	—	1	1 0043	1 0294
Dingle	— 18	—	1	1 0091	1 0343
Kiltanon	Dec 10.	—	1	1 0031	1 0282
Limerick	Dec Jan 1836	S 2	3	1 0000	1 0250
Youghal	Dec 29	—	2	9970	1 0219
London. .	April, 1836	L 3	3		1 0000
		L 4	3		1 0000
Dublin	April, May	L 3	4		1 0194
	April, May	L 4	4		1 0189
Limerick .	July 15, 16	S 2	3	1 0062	
Dublin	— 22, 23	—	3	1 0000	
Dublin	Oct 4	S 2	1	1 0000	1 0197
Bangor	Sept 21	—	1	1 0059	1 0257
London	June 1837, Oct 1838	S 2	13		1 0000
Dublin	July, Aug 1838	—	5		1 0183

The following Table contains the resulting values of the intensity at each station, with the latitudes and longitudes of the stations.

Table LXXVI.

Station	Lat	Long	Intensity	Station	Lat	Long	Intensity
Dublin .	53° 21′	6° 16′	1 0197	Ennis	52° 51′	8° 58′	1 0253
Limerick	52 40	8 35	1 0250	Cork	51 54	8 26	1 0189
Carlingford	54 2	6 11	1 0366	Waterford	52 16	7 8	1 0162
Armagh	54 21	6 39	1 0242	Broadway	52 13	6 24	1·0173
Coleraine	55 8	6 40	1 0194	Gorey	52 40	6 17	1 0129
Carn	55 15	7 15	1 0351	Rathdrum	52 55	6 14	1 0140
Strabane .	54 49	7 28	1 0299	Ballybunian	52 30	9 41	1 0335
Markree	54 12	8 26	1 0290	Valentia	51 56	10 17	1 0294
Ballina	54 7	9 7	1 0276	Dingle	52 8	10 17	1 0343
Belmullet	54 13	9 57	1 0292	Kiltanon	52 52	8 43	1 0282
Achill	53 56	9 52	1 0295	Youghal	51 57	7 50	1 0219
Galway	53 17	9 4	1 0285	Bangor .	54 39	5 42	1·0257

Of the foregoing results, those obtained at Carlingford and Coleraine are not included in the deduction of the isodynamic lines, on the grounds already stated. To all the others equal weights have been assigned; the local error bearing so large a

proportion to the error of observation, that the resulting probable error is but slightly diminished by the multiplication of the observations.

The following are the results of the calculation:

$$L = 1{\cdot}0252,\quad M = +{\cdot}000095,\quad N = +{\cdot}000058\,;$$

$$u = -31^\circ\ 20',\quad r = {\cdot}000111\,;$$

the central station being the same as before.

Captain Ross's observations of intensity (according to the statical method) were made in the autumn of the year 1838, with two needles designated as R L 3 and R L 4. They are contained in the following Table.

Table LXXVII.

	Station.	Date.	Hour.	Temp.	Angle.
			h m	°	° ′
Needle R L 4.	London	July 10 1838	5 0	68	− 13 33·2
		— 12	4 0	72	− 13 32·7
		— 12	5 0	72	− 13 30·7
		Mean...	4 40	70·7	− 13 32·2
	Waterford	Oct. 4	11 0	57	− 9 42·2
		— 4	12 0	57	− 9 39·0
		Mean...	11 30	57·0	− 9 40·6
	Cork	Oct. 6	4 20	58	− 9 22·9
		— 6	5 40	56	− 9 24·9
		— 7	0 15	60	− 9 36·0
		— 7	1 35	60	− 9 39·1
		Mean...	2 58	58·5	− 9 30·7
	Valencia	Oct. 12.........	0 30	53	− 8 36·2
		— 12.........	1 20	53	− 8 21·0
		— 13.........	11 0	51	− 8 12·1
		— 13.........	0 0	51	− 8 12·6
		Mean...	0 12	52·0	− 8 20·6
	Killarney	Oct. 19.........	0 15	59	− 8 44·4
		— 19	2 0	59	− 8 44·0
		Mean..	1 8	59·0	− 8 44·2
	Limerick.........	Oct. 22.........	0 40	61	− 8 48·5
		— 22.	2 0	61	− 8 51·4
		Mean...	1 20	61·0	− 8 50·0
	Dublin	Oct. 30	10 10	52	− 9 34·2
		— 30.........	11 0	52	− 9 33·7
		Mean...	10 35	52·0	− 9 34·0
	Londonderry ...	Nov. 6	0 45	49	− 5 27·6
		— 6	2 0	49	− 5 34·0
		Mean...	1 22	49·0	− 5 30·8
	London	Dec. 4	3 0	47	− 13 28·6
		— 4	4 30	47	− 13 28·0
		Mean...	3 45	47·0	− 13 28·4

	Station	Date	Hour	Temp	Angle
			h m		° ′
Needle R L 3	London	July 7	5 30	70°	– 26 38 4
		— 12	0 30	70	– 27 1 9
		— 12	1 30	70	– 27 4 8
		Mean	2 30	70 0	– 26 55 0
	Dublin . ..	Oct 30	11 30	52	– 24 27 3
		— 30 .	0 0	52	– 24 22 3
		Mean	11 45	52 0	– 24 24 8
	Londonderry	Nov 6 .	11 20	51	– 22 47 6
		— 6	0 40	51	– 22 49 8
		Mean	0 0	51 0	– 22 48 7
	Westport	Nov 14	0 40	45	– 22 19 7
		— 14	2 0	45	– 22 20 9
		Mean	1 20	45 0	– 22 20 3
	London .	Dec 5	3 0	45	– 26 32 9
		— 5	3 40	45	– 26 30 3
		Mean	3 20	45 0	– 26 31 6

With respect to these observations, Captain Ross observes: "The readings of R L 4 at Dublin, with the letters on the needle to the face of the instrument, gave 5° greater when facing the east, and 5° less when facing the west, than the mean of similar facings with the needle reversed on its axle. I therefore thought that the axle had got some bend, and was totally ruined; and accordingly used R L 3 always in future But at Londonderry I had some spare time, and thought I would try and find out the cause of this error, for I was sure it had sustained an injury.

"At Londonderry the mean of the readings E. and W, with the letters to the face of the instrument, was 2½ degrees less than the mean of similar readings with the needle reversed on its axle. I therefore believe that some considerable irregularity of the axle, about the point where the needle (with its letters to face of instrument) should rest at about –7°, has occasioned this error; and the circumstance of the Dublin observation coming out right, is merely accidental. In all other parts of the axle that I have tried, its readings agree very nearly with each other."

Under the circumstances above detailed, it seems necessary to reject the observations with RL 4 at Dublin and Londonderry.

The following Table contains the computed results of the foregoing observations, and the latitudes and longitudes of the stations In making the computation, no correction for temperature has been applied to the results of R L 3; the logarithmic correction of R L 4 is 000024.*

* See pages 157 and 158.

Table LXXVIII.

Station	Lat.	Long	Intensity	Station	Lat	Long	Intensity
Waterford	52° 16'	7° 8'	1·0197	Limerick	52° 40'	8° 35'	1·0243
Cork .	51 54	8 26	1·0211	Dublin	53 21	6 16	1·0186
Valentia	51 56	10 17	1·0272	Londonderry	55 0	7 20	1·0301
Killarney	52 3	9 31	1·0253	Westport	53 48	9 29	1·0329

In deducing the position of the isodynamic lines from these results, equal weights have been assigned to all, for the reason already given. The following are the results of the computation

$$L = 1{\cdot}0256,\ M = +\,{\cdot}000091,\ N = +\,{\cdot}000067;$$
$$u = -\,36°\ 29',\ r = {\cdot}000113$$

The results which have been above obtained respecting the position of the isodynamic lines in Ireland, are combined in the following Table:

Table LXXIX.

Observers	Method	No of Stations	L	M	N
Lloyd, Sabine, Ross..	Hor Vibr	20	1·0268	·000075	·000050
Lloyd, Sabine .. .	Statical .. .	22	1·0252	·000095	·000058
Ross	Hor Vibr	12	1·0276	·000086	·000067
Ross	Statical	8	1·0256	·000091	·000067

In deducing the mean values from the preceding results, we cannot, consistently with the character of the observations, assign to each a weight in proportion to the number of stations from which it is derived. If we compute the probable value of the intensity at each station, and compare it with that observed, we shall find that the differences are in general smaller in Captain Ross's observations than in those of the two earlier series, so that the individual results are entitled to a greater weight. This superiority is due, in great measure, to the circumstance that, in the latter series, all the observations were taken by the same observer, with the same instrument, and about the same time. On instituting a similar comparison between the results of the *two methods*, it will be found that, in Captain Ross's two series, the weight due to the results of the statical method is very nearly *double* of that in the method of vibration, the probable errors being, nearly, in the ratio of 1 to $\sqrt{2}$. The same disparity between the methods is not

seems to be fully accounted for by the imperfection of the instrument used by me in the statical observations, the effect of the magnetism of the limb (page 106 *et seq.*) being in this case uncorrected.

The equations of condition afford the means of deducing the weights of the preceding results, on the supposition that there is no constant error. But as this cannot be supposed, we are left to a certain extent unguided. On the whole, we shall probably be not far from the truth in assigning *equal* weights to each of the former results, notwithstanding the disparity in the number of stations. The following are the mean values thus deduced

$$L = 1{\cdot}0263, \quad M = +\ {\cdot}000087, \quad N = +\ {\cdot}000061.$$

Accordingly, the probable value of the intensity at the central station (lat. $= 53° 21'$, long. $= 8° 0'$) is

$$1{\cdot}0263$$

And from the mean values of M and N we obtain, for the direction of the isodynamic line passing through that station,

$$u = -35° 0',$$

and for the rate of increase of the intensity in the direction perpendicular to that line,

$$r = {\cdot}000106.$$

In order to reduce the intensity results of the present survey to *absolute* measures, it is only necessary to determine the absolute intensity of the magnetic force at some one of the base stations, according to the method of Professor Gauss. This will be done, ere long, in Dublin; and it is therefore important that the ratio of the intensities in Dublin and London (with which latter station all the others are compared) should be accurately known.

For the determination of this ratio we have abundant materials in the present memoir. The ratio of the horizontal intensities in Dublin and London, as deduced from the first series, was found to be ·9399, the result being equivalent to the mean of eleven distinct comparisons. If we combine with this the result obtained by Captain James Ross, namely, ·9383, the mean value of the horizontal intensity in Dublin is found to be

$$\cdot 9398,$$

the horizontal intensity in London being unity. But the dip in London corresponding to the mean epoch of these observations (the 1st of January, 1837) is 69° 19'·6, and that in Dublin is 71° 1'·2, wherefore the total intensity in Dublin is

$$1{\cdot}0201,$$

the total intensity in London being unity.

Again, we have found that the intensity in Dublin, as deduced by the statical method from the observations made by Major Sabine and myself, is expressed by the number

the intensity in London being unity The value of this ratio obtained by Captain Ross in 1838 is 1 0186, and the former result being equivalent to the mean of six distinct comparisons, the final mean is 1 0195

Of these results, deduced by the two methods, the difference is only 0006, and we should therefore err very little from the truth in taking their arithmetical mean But the probable error of a single comparison in the latter method is so much less than in the former, that we shall certainly be nearer to the truth in adopting the latter result. We shall accordingly consider the number 1 0195 as expressing the ratio of the intensities of the magnetic force in Dublin and London

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Report resumed by Major Sabine.

Collecting in one view the values of u and r resulting from the several series of intensity observations, we have as follows:

TABLE LXXX.

	Method	Observer	No of Stations	Mean Geog. Posit.		u	r
				Lat	Long		
England	Statical	Lloyd	12	52° 01′	1° 50′	−54° 49′	·000082
	Statical	Phillips	24	53 49	2 08	−47 37	000090
	Statical	Sabine	20	52 36	2 11	−52 27	000079
	Hor Vibr	Ross, Sabine, Lloyd	27	52 43	2 18	−47 14	000094
		Mean	74	52 48	2 07	−50 48	000086
Scotland	Statical	Sabine	19	56 22	4 01	−52 15	000136
	Statical	Ross	9	56 52	2 45	−40 38	000106
	Hor Vibr	Sabine	21	56 30	4 10	−55 46	000143
	Hor Vibr	Ross	12	56 56	2 58	−43 32	000125
		Mean	61	56 40	3 30	−50 02	000132
Ireland	Statical	Lloyd, Sabine	22	53 21	8 00	−31 20	000111
	Statical	Ross	8			−36 29	000113
	Hor Vibr	Lloyd, Sabine, Ross	20			−33 48	000090
	Hor Vibr,	Ross	12			−38 00	000109
		Mean	62	53 21	8 00	−34 06	000104

The values of u in England and Scotland, or the angle which the isodynamic lines in those countries make with the meridian,

results. But the values of r, or the rate of increase of the intensity corresponding to equal geographical spaces, differ considerably, and give a decided indication that the spaces between the isodynamic lines are less in Scotland than in England. If we examine the partial results obtained in the two countries by the different observers, and by the different methods of observation, we perceive that all the series are consistent in this indication. The lines which are selected for representation in the map are those of unity (passing through London), of 1·01, 1·02, and 1·03: the mean distance between the lines, which thus differ ·01 in the values of the intensity they represent, is in England 116, and in Scotland 75 geographical miles; the partial results vary in England from 106 to 126 miles, and in Scotland from 69 to 94 miles.

Whatever may be the cause of this difference in the value of r in the northern and southern portions of the island, it is obviously much too great to be taken as a regular part of a general progression, as in its extension towards the N.W. and S.E., the separation between the lines would in the one case be soon rendered extravagantly small, and in the other extravagantly great.

In order to deduce the position of the several isodynamic lines in best conformity with the observations, it is particularly necessary, under such circumstances, to derive each line from those observations only which are in its immediate vicinity; and thus to reduce within very small limits the effect on each of the rapidly-changing and somewhat uncertain values of r. We require, for this purpose, only its approximate values in the vicinities of the respective lines; and without entering into nice calculations where we have not a sufficiently satisfactory basis, we may provisionally assume these values as follows; always remembering, that any inaccuracy in the assumption will produce an opposite effect on the deductions from the observations which are on either side of each isodynamic line, and that such opposite effects will counterbalance each other in the mean position assigned to the line.

Approximate values of r in England and Scotland, in the vicinity of the several isodynamic lines:

Line of 1·0 ; r = ·00008
1·01, r = ·00009
1·02, r = ·00011
1·03, r = ·000135

The mean value of r in Ireland, derived from the several series in that country, is ·000104 or ·000106, (page 185,) which corresponds so nearly with the value which might be interpolated from the results in England and Scotland for the latitude of the central geographical position in Ireland, that we may safely

If we compare the mean value of u derived from the Irish series, $-34° 6'$ (varying in the several partial results from $-31° 20'$ to $-38° 00'$), with its mean values in England and Scotland $-50°$, (the partial results varying from $-40° 38'$ to $-55° 46'$), we find, notwithstanding the amount of the partial differences, a general and consistent indication that the isodynamic lines are less inclined to the meridian in Ireland than in Great Britain. The two Irish series which give the least values for this angle, are those which were the earliest obtained,—which had consequently the disadvantages of less experience in the observers, and less perfection in the instruments, and of combining in one series observations at different epochs, and results by different observers, and with different instruments. The two series of Captain Ross were, on the other hand, obtained by one observer with the same instruments, were well distributed over the country, and were made in immediate and rapid succession. We may therefore safely infer, as Mr. Lloyd has done (pages 184, 185), that the values of u derived from Captain Ross's series are entitled to weight beyond the proportion which the number of the stations which they represent bears to the number of stations in the other Irish series. Still the difference in the angle with the meridian in Ireland and in Great Britain cannot, in any consistency with the observations, be less than several degrees I have employed $-35°$, the value deduced by Mr Lloyd, pages 184 and 185, as the general mean value of u in the Irish deductions.

If we compare generally the mean results of the horizontal with those of the statical series, we are not able to discover any apparent systematic differences whatever in regard to the values of u and i The individual observations by the horizontal method do indeed exhibit much greater discordances with each other than is the case in the statical method. This has been already shown in detail in the analysis of the observations by the two methods in Scotland, in pages 20, 21, of the Sixth Report of the British Association and Mr. Lloyd has elsewhere pointed out the causes of the advantage in this respect of the method for which we are indebted to him. Although, therefore, the accordance of the two methods, when the observations are grouped, is a satisfactory confirmation of the conclusions which they unite in establishing, the horizontal observations are less fitted than the statical to be employed in a graphical representation of the particular nature adopted in this report, in which the discordances of individual observations are brought strongly into notice, and if exceeding a certain limit might produce inconvenience, by in some degree perplexing the judgment In extreme cases they might entirely mislead it, as, for example, if the point furnished by an observation for a particular line should fall nearer to an adjacent

line than to the one to which it really belongs, and this will occur whenever, from accidental causes of any kind, the discordance exceeds in amount half the interval between the lines which are represented. Such extreme cases are frequent in the horizontal observations; but are of very rare occurrence in the statical. Of the 114 statical results, there are only five which have been omitted in the graphical representation, (though of course included in the table). Four of these are, Ballybunian, Dingle, Gorey, and Rathdrum, all in the south of Ireland, and amongst our earliest observations. The two first named were my stations, and the intensity is in excess,—the two others were Mr Lloyd's stations, and the intensity is in defect of the general body of the results, the omission of the four should consequently have no effect on the position of the lines.

The fifth observation omitted in the map is Captain Ross's at Berwick, which would furnish a point for the line of 1·03 in a geographical position which is nearer the line of 1·02.

The evidence supplied by the collective horizontal observations is, however, too valuable to be dispensed with in the representation. I have collected in the following Table the values of the intensity derived, for the respective mean geographical positions, from the combined observations of each series, both horizontal and statical. In the map the central stations are designated thus, +, with the initial of the observer annexed, and the points furnished by the respective intensities for the nearest adjacent line thus, *, with H or S, according as the series was horizontal or statical, and a figure is added expressing the number of stations contributing to the result. In Ireland the one central station has been taken by Mr. Lloyd as common to all the series, and the initials of the observer, therefore, are transferred to the points.

TABLE LXXXI.

Statical

Observer	Mean Geographical Position: Lat	Long	Intensity
	° ′	° ′	
P	53 49	2 08	1·0136
S	52 36	2 11	1·0075
L	52 01	1 50	1·0048
S	56 22	4 01	1·0290
R	56 52	2 45	1·0277
L, S	53 21	8 00	1·0252
R	53 21	8 00	1·0256

Horizontal

Observer	Mean Geographical Position: Lat	Long	Intensity
	° ′	° ′	
R, S, L	52 43	2 18	1·0087
S	56 30	4 10	1·0285
R	56 56	2 58	1·0302
L, S, R	53 21	8 00	1·0268
R	53 21	8 00	1·0276

The General Table of the intensity results by the statical method is analogous to the General Table of the Dip observations it appears, therefore, to require no separate explanation. The intensities which exceed 1 035 belong to the line of 1·04, of which no representation has been attempted, because the results on which it would rest are all, with a single exception, on one side of the line. The stations to which these results belong are, however, retained in the map, and are accompanied in each case by the numerical value of the observed intensity

General Table.

Intensity Statical Method.

OBSERVATIONS					DEDUCTIONS				
Station	Lat	Long	Observer	Intensity	Δ Lat	Δ Long	Isodynamic Line of 1 03 in Lat	Isodynamic Line of 1 03 in Long	Values of u and r
Lerwick	60 09	1 07	R	1 0358	These stations belong to the isodynamic line of 1 04, which is not drawn in the map				
Kirkwall	59 00	2 58	R	1·0373					
Gordon Castle	57 37	3 09	S	1 0380					
Golspie	57 58	3 57	S	1 0360					
Inverness	57 28	4 11	S	1 0382					
			R	1 0378					
Loch Slapin	57 14	6 02	S	1 0427					
Carn	55 15	7 15	L	1 0351					
Berwick	55 45	2 00	R	1 0254	+25	+39	56 10	2 39	$u = -50°$, $r = 000135$
Aberdeen	57 09	2 05	R	1 0268	+18	+28	57 27	2 33	
Alford	57 13	2 45	S	1 0294	+ 4	+ 5	57 17	2 50	
Newport	56 25	2 55	S	1 0277	+13	+20	56 38	3 15	
Kirkaldy	56 07	3 09	S	1 0279	+11	+17	56 18	3 26	
Blairgowrie	56 36	3 18	S	1 0310	− 6	− 9	56 30	3 09	
Braemar	57 01	3 25	S	1 0269	+17	+26	57 18	3 51	
Dunkeld	56 35	3 33	R	1 0267	+19	+28	56 54	4 01	
Helensburgh	56 00	4 41	S	1 0258	+23	+36	56 23	5 17	
Cumbray	55 48	4 52	S	1 0287	+ 8	+12	55 56	5 04	
Glencoe	56 39	5 07	S	1 0324	−13	−20	56 26	4 47	
Loch Ranza	55 42	5 17	S	1 0261	+22	+33	56 04	5 50	
Campbelton	55 23	5 38	S	1 0296	+ 2	+ 3	55 25	5 41	
Bangor	54 40	5 40	S	1 0257	+25	+57	55 05	6 37	$u = -35°$, $r = 00010$
Londonderry	54 59	7 19	R	1 0301	− 1	− 1	54 58	7 18	
Strabane	54 49	7 28	L	1 0299	+ 1	+ 1	54 50	7 29	
Markree	54 12	8 26	L	1 0290	+ 6	+13	54 18	8 39	
Kiltanon	52 52	8 43	S	1 0282	+10	+23	53 02	9 06	
Ennis	52 51	8 57	L	1 0253	+28	+64	53 19	10 01	
Galway	53 17	9 04	L	1 0285	+ 9	+20	53 26	9 24	
Ballina	54 07	9 07	L	1 0276	+13	+32	54 20	9 39	
Westport	53 48	9 29	R	1 0329	−17	−39	53 31	8 50	
Killarney	52 02	9 30	R	1 0253	+28	+64	52 30	10 34	
Ballybunian	52 30	9 41	S	1 0335	−21	−48	52 09	8 53	
Belmullet	54 13	9 57	L	1 0292	+ 5	+11	54 18	10 08	
Achill	53 56	9 52	L	1 0295	+ 3	+ 7	53 59	9 59	
Valencia	51 56	10 17	S	1 0294	+ 9	+22	52 05	10 39	
			R	1 0272					
Dingle	52 08	10 17	S	1 0313	−25	−58	51 43	9 19	

General Table—(*continued*).

OBSERVATIONS.					DEDUCTIONS				
Station.	Lat	Long.	Observer	Intensity	Δ Lat.	Δ Long.	Isodynamic line of 1·02 in Lat	Isodynamic line of 1·02 in Long.	Values of s and r.
Thirsk	54° 14′	1° 21′	P	1·0155	+31′	+45′	54° 45′	2° 06′	
Newcastle	54 58	1 37	P, R, S	1·0173, 1·0165, 1·0147	+26	+38	55 24	2 15	s = −50°; r = ·000110.
Alnwick Castle...	55 25	1 42	S	1·0159	+28	+41	55 53	2 23	
Dryburgh	55 34	2 39	S	1·0190	+ 1	+ 1	55 35	2 40	
Melrose	55 35	2 44	S	1·0208	− 6	− 8	55 29	2 36	
Stonehouse	54 55	2 44	R, S	1·0178, 1·0176	+17	+25	55 12	3 09	
Penrith	54 40	2 45	P	1·0184	+11	+16	54 51	3 01	
Carlisle	54 54	2 54	P	1·0198	+ 1	+ 2	54 55	2 56	
Bowness...........	54 22	2 55	P	1·0182	+13	+18	54 35	3 13	
Patterdale	54 32	2 56	P	1·0181	+14	+19	54 46	3 15	
Coniston	54 22	3 05	P	1·0196	+ 3	+ 4	54 25	3 09	
Edinburgh	55 57	3 11	S	1·0231	−22	−31	55 35	2 40	
Whitehaven	54 33	3 33	S	1·0176	+16	+24	54 49	3 57	
Glasgow	55 51	4 14	S	1·0232	−23	−32	55 28	3 42	
Jordan Hill	55 54	4 21	R, S	1·0236, 1·0259	−34	−48	55 20	3 33	
Douglas.......	54 10	4 27	P	1·0208	− 6	− 8	54 04	4 19	
Castleton	54 04	4 40	P	1·0203	− 2	− 3	54 02	4 37	
Peelton	54 13	4 43	P	1·0192	+ 6	+ 8	54 19	4 51	
Loch Ryan	54 55	4 58	S	1·0221	−15	−21	54 40	4 37	
Dublin	53 21	6 16	L, R, S	1·0195	+ 3	+ 7	53 24	6 23	
Broadway	52 13	6 24	L	1·0173	+15	+36	52 28	7 00	
Armagh............	54 21	6 39	L	1·0242	−24	−57	53 55	5 42	
Waterford	52 16	7 08	L, R	1·0162, 1·0197	+12	+26	52 28	7 34	s = −36°; r = ·00010.
Youghal	51 57	7 50	S	1·0210	−11	−25	51 46	7 25	
Cork	51 54	8 26	L, R	1·0189, 1·0211	0	0	51 54	8 26	
Limerick	52 40	8 36	S, R	1·0250, 1·0243	−27	−63	52 13	7 33	

General Table—(*continued*).

Station.	Lat	Long	Observer	Intensity	Δ Lat.	Δ Long.	Isodynamic line of 1·01 in Lat	Isodynamic line of 1·01 in Long	Values of x and c
	OBSERVATIONS.				**DEDUCTIONS.**				
Flamborough	54° 08′	0° 08′	P	1·0083	+14′	+19′	54° 22′	0° 27′	x = 50°; c = ·00090
Scarborough	54 17	0 24	P	1·0103	− 3	− 4	54 14	0 20	
Whitby	54 29	0 37	P	1·0135	−29	−43	54 00	−0 01	
York	53 58	1 05	P	1·0126	−22	−31	53 36	0 34	
Doncaster	53 31	1 07	P	1·0088	+ 3	+ 5	53 34	0 12	
Hambleton	54 20	1 15	P	1·0134	−28	−41	53 52	0 34	
Osmotherley	54 22	1 18	P	1·0128	−24	−34	53 58	0 44	
Sheffield	53 22	1 31	P	1·0124	−20	−28	53 02	1 03	
Birmingham	52 28	1 53	P	1·0105	− 4	− 6	52 24	1 47	
Shrewsbury	52 43	2 45	L / S	1·0077 / 1·0057	+27	+38	53 10	3 23	
Calderstone	53 23	2 53	P	1·0106	− 5	− 7	53 18	2 46	
Birkenhead	53 24	3 00	L / P	1·0112 / 1·0146	−24	−33	53 00	2 27	
Coed	53 11	3 12	P	1·0110	− 8	−12	53 03	3 00	
Brecon	51 57	3 21	S	1·0060	+35	+46	52 32	4 07	
Merthyr	51 43	3 21	S	1·0081	+17	+23	52 00	3 44	
Dunraven Castle	51 28	3 37	S	1·0078	+20	+26	51 48	4 03	
Aberysthwith	52 24	4 05	S	1·0100	0	0	52 24	4 05	
Holyhead	53 19	4 37	L	1·0144	−38	−53	52 41	3 44	
Rathdrum	52 55	6 12	L	1·0140	−34	−48	52 21	5 24	
Gorey	52 41	6 15	L	1·0129	−25	−34	52 16	5 41	

Station.	Lat.	Long	Observer.	Intensity.	Δ Lat.	Δ Long.	Isodynamic line of 1·00 in Lat.	Isodynamic line of 1·00 in Long.	Values of x and c.
Margate	51° 23′	−1° 23′	S	0·9970	+29′	+39′	51° 52′	−0° 44′	x = 50°; c = ·00080
Dover	51 08	−1 19	S	0·9945	+53	+70	52 01	−0 09	
Lynn	52 47	−0 25	L	1·0030	−29	−39	52 18	−1 04	
Eastbourne	50 47	−0 16	F	0·9957	+51	+68	51 38	0 52	
Cambridge	52 13	−0 07	L	1·0001	− 1	− 1	52 12	−0 08	
Brighton	50 50	0 08	L	0·9955	+44	+58	51 34	1 06	
Worcester Park	51 23	0 17	S	1·0006	− 6	− 7	51 17	0 10	
Eastwick Park	51 17	0 19	F	0·9993	+ 7	+ 8	51 24	0 27	
Tortington	50 50	0 34	S	0·9990	+10	+13	51 00	0 47	
St. Clair's	50 44	1 08	P	1·0002	− 2	− 2	50 42	1 06	
Ryde	50 44	1 10	L	0·9972	+27	+35	51 11	1 45	
Salisbury	51 04	1 47	L	1·0006	− 6	− 7	50 58	1 40	
Combe House	51 31	2 34	F	1·0026	−26	−34	51 05	2 00	
Clifton	51 27	2 36	L	1·0030	−29	−39	50 58	1 57	
Chepstow	51 38	2 41	L	1·0041	−40	−53	50 58	1 48	
Hereford	52 04	2 44	L	1·0046	−44	−59	51 20	1 45	
Lew Trenchard	50 40	4 10	S	1·0015	−43	−56	49 57	3 14	
Falmouth	50 09	5 06	F / S	1·0018 / 1·0015	−17	−22	49 52	4 44	

Extension of the Isoclinal and Isodynamic Lines into Meridians East and West of the British Islands.

Having thus completed the representation of the principal lines of dip and intensity passing across the British Islands, it appears desirable to trace their prolongation on either side, until they are brought in connexion with the lines of the same value in adjacent meridians to the east and west, as determined by recent and satisfactory observations. As a single line of each of the phenomena will suffice to exhibit this connexion, I have selected for that purpose the isoclinal line of 70°, and the isodynamic line of 1·03.

In Plate III. the portion of the isoclinal line, which is represented by an unbroken line, has been determined by the observations contained in this report. In its eastern prolongation it passes through countries where its position is well assured by observations of higher amount on the one side, and of lower amount on the other, too numerous for insertion in a map on so small a scale, and too well known to need a recapitulation here. Towards the north-eastern extremity of the map, the position of Gros Novgorod is marked in lat. 58° 31′ and long. 31° 19′, where M. Erman observed the dip 70° 26′·1 on the 13th of July, 1828. This observation, reduced to January 1837, by allowing an annual diminution of 3′, becomes 70° 00′·6: the line of 70° is therefore made to pass through this station. To the west of the British Islands, the line is prolonged until it is brought in connexion with M. Erman's observations on his homeward passage, in August 1830. For this purpose I have formed M. Erman's observations into two groups, each of three stations, as follows:

1830.	Lat.	Long.	Dip.	
Aug. 19	41° 27′	327° 25′	70° 03′·6	70° 19′·4
— 20	42 29	328 34	69 47·6	
— 21	44 22	330 55	71 07·1	
— 22	46 46	335 42	70 18·5	70 06·3
— 24	47 47	343 58	69 46·0	
— 25	47 46	344 25	70 14 9	

Allowing, as in Britain, an annual decrease of 2′·4, the dips in January 1837, corresponding to the mean positions of these groups, are as follows:

Lat	Long	Dip
42° 46′	328° 58′	70° 04′
47 26	341 22	69 51

These positions are marked in the Map, and the isoclinal line of 70° is prolonged to the westward in correspondence with the mean of M. Erman's observations thus corrected for epoch.

To connect the isodynamic line of 1 03 with intensities of the same value in the adjacent meridians, it is necessary to express the value of this line in terms of the arbitrary scale employed by Continental observers, in which the force in London = 1·372 In this scale the line of 1 03 corresponds in value to (1 03 × 1·372 =) 1 413 The portion of this line which is represented in the Map by an unbroken line has been determined by the observations contained in this report Its prolongation to the eastward is traced in conformity with M. Hansteen's observations in Norway, and with MM Hansteen's and Erman's in Russia The station marked in lat. 60° 11′ and long 10° 20′ is the mean geographical position of a group of six stations in Norway, not far removed from each other, for which M. Hansteen's observations in 1821, 1823, and 1825, gave a mean intensity of 1 414 (7th Report, British Association, page 49). At Gros Novgorod (lat 58° 31′, long. 31° 19′) the determinations of MM Hansteen and Erman accorded in assigning 1 412 as the value of the force (7th Report, British Association, page 51), and the line has been still further extended, in conformity with the observations of the same gentlemen at Moscow, in lat 55° 46′, and long 37° 36′, their mean determination being 1·405. The position of the line in its western prolongation has been drawn in conformity with the values of the intensity at the islands of Terceira and Madeira, contained in the general table of the memoir on the magnetic intensity already referred to, viz.

Terceira	Fitz Roy	1836	1 457	
Madeira	Sabine	1822	1 373	1 375
	King	1826	1 377	

Both stations are included in the Map. The values of the force at M. Erman's dip stations in the same quarter, determined by the same excellent observer, are also inserted in the map, as affording corroborative evidence of the correct position of the isodynamic line in this its western extension.

In order to render the view in this Map of the magnetic phenomena in the British Islands more complete, I have added the direction, shown by arrows, of the horizontal or compass needle at three extreme stations, determined by Captain James Clark Ross, viz Lerwick, in the Shetland Islands, Valencia, at the S W extremity of Ireland, and Bushey, near London. The geographical positions of these stations, and the variations observed at them, are as follows, the latter being the *mean* variation at the epoch named, obtained by observations repeated every fifteen minutes from 7 A.M. to 7 P M for several successive days.

Station	Date	Lat	Long	Variation
Lerwick	July 26, 1838	60° 09′	1° 07′ W	27° 08′ 35″ W
Valencia	Oct 13, —	51 56	10 17 W	28 41 52 W
Bushey	April 3, —	51 38	0 22 W	23 59 24 W

REPORT ON THE MAGNETIC ISOCLINAL AND ISODYNAMIC LINES IN THE BRITISH ISLANDS.

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